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Land Use and Land Cover Changes of Gile National Park Buffer Zone from 1999 to 2019, Central Mozambique

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Abstract: Land use/land cover change (LULCC) is a major issue in global environmental change. Loss of functionality of protected areas from surrounding land use modification is a daunting problem. The objective of this study was therefore to investigate LULCC and its causes in the buffer zone Gile national park, central Mozambique. Landsat imagery of 1999, 2009 and 2019 were used. Study area was categorized in to six LULC classes. Supervised classification was used for image classification whereas analysis and quantification of spatio-temporal dynamics of the LULCC were done through Landsat image pre- processing, classification and post-processing using QGIS 2.8.1 and ArcMap 10.1. Dense miombo wood lands are mainly distributed in the western and southern part of the park, while agricultural land is concentrated in the northern, eastern and south west of the park. The overall accuracy for 1999, 2009 and 2019 were 90%, 90% and 91% respectively. Kappa statistics showed a strong agreement. Dense and open miombo woodland are the most dominant land cover classes, covering 6655 ha (43.61) and 44190.09 ha (28.95%) of the total land use in 1999. From 2009 to 2019 agricultural land expanded by 23385.42 ha (15.3%) of its 1999 area coverage. Of the total land cover about 34.57 and 40.86 % of land covers remained unchanged for 1999 to 2009 and 2009 to 2019 correspondingly. Within 20 years about 14.85 % of dense miombo woodland has been changed to other land uses which means degraded. The rate of forest loss from 1999-2019 were 1, 237.14 ha/yr. The highest annual rate of deforestation (4.05%) recorded during the period of 1999 to 2009. The result of House hold interview, focus group discussions and key informants also showed that slash and burn agriculture, settlement and forest concession were the major causes of LULCC. The adverse impacts of LULCC were associated with the underlying factors related to human activities. To reverse these challenges, there must be broad-scale restoration projects around the area supported by wariness creation and incentive mechanisms to conserve forests for forest users.

Key words: Miombo Woodland · Land Use Land Cover Change · Buffer Zone of National Park

INTRODUCTION

Miombo woodland is a vast African dry land forest ecosystem covering close to 2.0 million km^2 across southern Africa [1] and are highly valued of its ecological functions and ecosystem service [2, 3] Land use/land cover change (LULCC) is a major issue in global environmental change [4, 5]. Rapid worldwide population growth accompanied by human activities has led to rapid LULCC [4, 6, 7]. LULCC has become a central and important component in current strategies for managing natural resources and monitoring environmental changes [8]. LULCC is an important factor affecting carbon cycling process and bringing changes to carbon sources and

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sinks in terrestrial ecosystems through changes in biophysical properties of the land-cover [9-11]. A quarter of the total carbon emission by human activities is caused by land use changes as a result of deforestation and forest degradation [12, 13].

Loss of functionality of protected areas from surrounding land-use modification is a particularly daunting problem in developing nations. These areas are where land-use change has been occurring rapidly over the last 25 years and is projected to continue [14]. In opposite, the resources in and around protected areas are more critical to people living adjacent to it [15, 16]. As such, to ensure the effectiveness of protected areas, it is necessary to understand changes driven by the surrounding landscapes [2, 17]. Knowledge of LULCC over a time horizon can be of great importance in the context of preparing concrete local, regional and national land management measures and can be used to reverse land use issues, illegal occupations, habitats destruction, ecological and natural resource deterioration, loss of biodiversity [18, 19]. Mozambique is engaged in a pilot project for REDD+ in two provinces, including Zambézia, establishing a series of new management and monitoring programs such as restoration of degraded lands; strengthening protected areas management and the implementation of the Zambézia Landscape Program (ZILMP). In Mozambique little is known about land use land-cover changes at the national level and are still very incipient [19, 20]. Drivers of deforestation and forest degradation varies per province, based on forest type, economic, social and natural characteristics. Shifting agriculture has a greater impact on emissions (60%) in the central part of the country [21]. A first order estimation of emissions resulting from the three most important causes of forest degradation (timber exploration, production of firewood and charcoal and wildfires), predicted that forest degradation is responsible for almost 30% of total emissions [22]. This scenario reveals the importance and urgent need of further studies about LULCC in different areas of the country to provide useful and timely information for better understanding of LULCC [19]. Gile National Park (Gile NP) which hosts various endangered wildlife species was created in 1932, originally as a game reserve for hunting and proclaimed as a conservation area in 1999, first as a National Reserve [23] and very recently (May 2020) as a National Park [24].

The Gile NP is divided between a fully protected core area (2, 861 km^2) and a buffer zone (1, 671 km^2). It is the only protected area in Mozambique with no permanent settlements in its core area and represents one of the largest areas of uninterrupted Miombo woodland in the northern part of the country. It has been suffering from severe threats of LULCC at its buffer zone. Community living in the buffer zone regularly open new fields through clearing forested areas, this phenomenon with demographic pressure is worsening on forest land [23].

Remote sensing have been widely used to classify land cover and played a key role in determining the loss of forest cover at a landscape level since the 1990s [2, 25]. Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement [3, 17, 26]. Land use/cover change detection is very essential for better understanding of landscape dynamic during a known period of time [26] and its study has been emerged as an important research concern as hence it cause serious environmental changes [27]. This requires the present and past land use/ cover data of the area. The objective of this study was therefore (1) to analyze land use and land cover changes in the past 20 years in the Gile NP buffer zone and (2) To identify causes of LULCC in the Gile NP buffer zone, central Mozambique.

MATERIALS AND METHODS

Study Area: The study was conducted in buffer zone of Gile NP in Zambezia Province, central Mozambique, at about 1561.46 km North of Maputo, capital city of the country. Gile NP is situated between two districts namely Pebane and Gile and is situated in the north-eastern part of the Province Figure 1. About 12, 500 inhabitants live in the Gile NP buffer zone. About 89% of the population is dedicated to subsistence agriculture, based on "slash and burn" techniques [28].

Methods

Remote Sensing Data Collection: Landsat TM (Thematic Mapper) and Landsat 8 OLI (Operational Land Imager) imagery with a 30-m spatial resolution for the years of 1999, 2009 and 2019 were downloaded from United States Geological Survey (USGS), archive at https://ers.cr.usgs.gov/ and used [29] (Table 1). To minimize the effects of seasonal variations in vegetation patterns throughout a year, the image selection was made for the same season for all years. Landsat 5 images was used for (1999 and 2009) whereas Landsat 8 was used (2019) for evaluating LULCC. The images was geo-referenced for WGS 84/UTM zone 37S and the general images processing were shown (Figure 2).

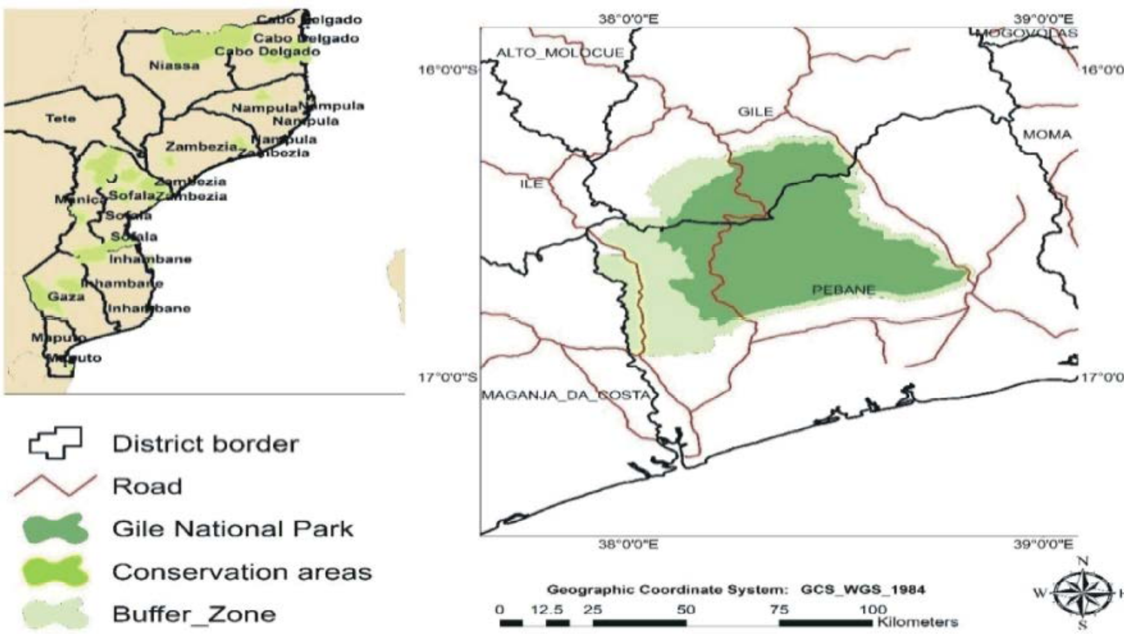

Fig. 1: Map of the study area

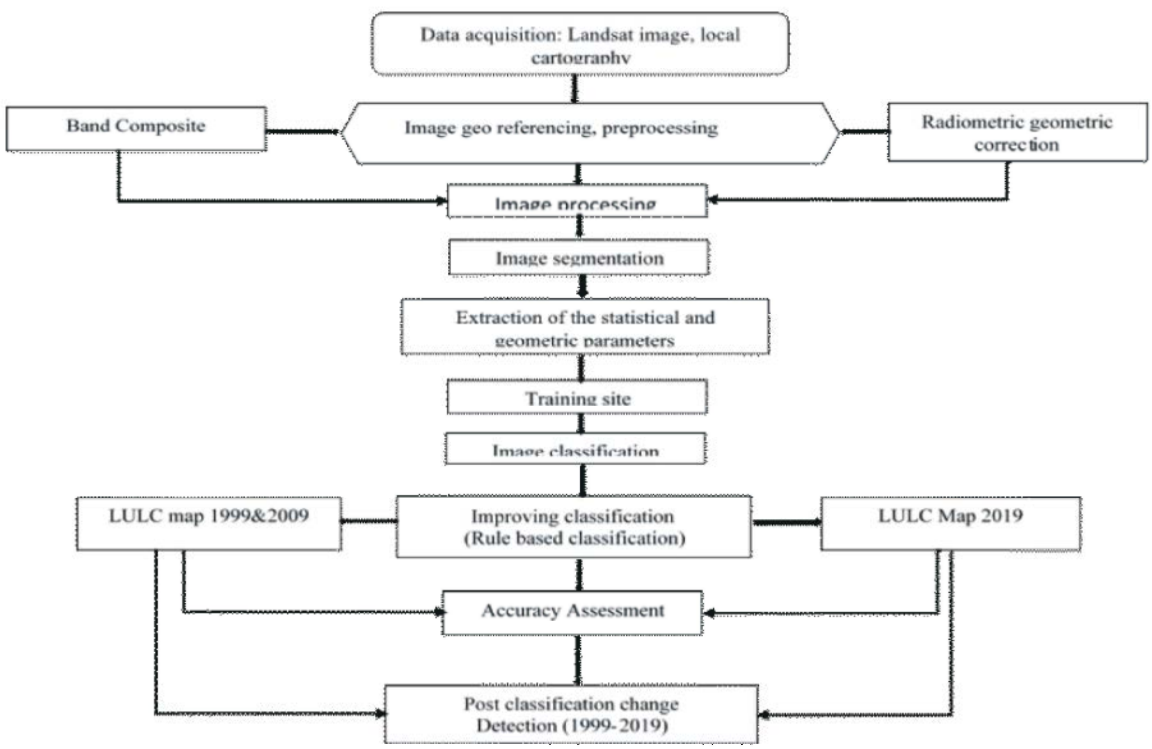

Fig. 2: Flowchart of land use land cover/change detection

Table 1: Landsat's scenes, sources and specifications used in this study (Path/row =165/071, 165/072 for all image, TM: Thematic Mapper; OLI-TIRs: Operational Land Imager and Thermal Infrared Sensor)

No	Acquisition Date	Satellite Image	Sensor	Spatial Resolution	Used Bands	Sources
1.	January 1999	Landsat TM	TM	30	1-5, 7	USGS
2.	November 2009	Landsat TM	TM	30	1-5, 7	USGS
3.	October 2019	Landsat8 OLI	OLI-TIRs	30	1-7, 9	USGS

Table 2: Land Use/Land Cover (LULC) classes used and their descriptions.

No	LULC Classes	General Description
1.	Dense Miombo woodlands	Part of the Mozambican forest category of Semi-deciduous Forests with a canopy cover above 50%. Usually correspond to an undisturbed state of Miombo [30].The classic miombo trees *Brachystegia, Julbernardia* and *Isoberlinia* dominate the woodlands
2.	Open Miombo woodland	Part of the Mozambican forest category of semi-deciduous forests with a canopy cover between 30-50% [30]. The classic miombo trees *Brachystegia, Julbernardia* and *Isoberlinia* dominate the woodlands with other tree species such as *Pterocapus angolensis, Albizia sp*. and *Afzelia quanzensis*.
3.	Shrub land	Refers to stands of broad-leafed (semi)-evergreen or (semi)-deciduous shrubs (height < 5 m) with canopy cover less than 40%. Emergent trees may occasionally occur [31]
4.	Agricultural land	Areas used for crop cultivation (both annual and perennial), fallow plots, scattered rural settlements, some pastures and plantations around settlements. Sparsely located settlements and roads constructed from earthwork were included here as it was difficult to separate them from agricultural lands.
5.	Water Bodies	All natural water bodies (rivers, inland water, etc.).
6.	Others	Rocks, bare soils and all land use not considered in the above class

Based on Mozambique forest classification system, National Directorate of Geography and Cadastre (DINAGECA) 1998 and Gile NP land use management plan, the study area were categorized in to six land use land cover (Table 2). All land use classes of interest were selected and defined carefully to classify remotely sensed data into the intended land use and land cover categories.

Socio-Economic Data: Socio-economic survey were used to collect information from local community about local resources, resources use and causes of LULCC. Although there are different techniques for the socio-economic surveys, based on the purpose of the study, household interview, key informant interview (KII) and focus group discussion (FGD) were used [16].

There is about 40 community in the buffer zone of which 10 community were randomly selected for formal interviews as there was no major differences among community in terms of forest cover and their activities at the moment in the area. Next to this, households' sample frame was established by collecting complete list of HH head record from their respective administrative post office. The sample frame were all household heads living in the identified community and finally the selections of sample households was proportional to each community. Accordingly, the total numbers of household living in selected community for target area was 700. After getting the total number of household heads living in each selected community, a total of 200 respondents which was about (28%) of the selected household were chosen using simple random sampling techniques from the total household [32]. Allocations of the number of sample households to each community was proportional to the number of household head living in each community.

Based on community's settlement and proximity of their locations to national park, four communities from each direction of the national park (North, South, West and East) at the buffer zone were selected for FGD. These community cover district of Pebane and Gile (Figure 1). A total of four FGDs, one in each community were carried out. Each FGDs comprises eight to ten participants drawn from the members of the community. Members of FGD were selected with the help of community leaders, knowledgeable person about their background and expert from the national park. Twelve KIIs were held with district level and national park experts of forest and land use administration. During KIIs and FGDs, open-ended questions having information about status of LULCC in the buffer zone, driving cause of LULCC, the relationship among the biophysical environment, institution, socio-economic activities and demography were used. The main focuses were to get enough information about the past and present trend of LULCC and identify driving cause of the changes.

To better understand the major observed problems of the study area and resource use and management practices, field walks and informal talks with people in their farms/fields were used. Farmers were asked to explain which area of the buffer zone were changed and explained why the change had occurred. They also asked to explain how their socio-economic activity contributes to the land-use land cover change. Field observation was carried out based on checklists designed in advance to observe the situation in the buffer zone and photographs of important sites were taken to enrich the study.

Data Analysis

Remote Sensing Data Analysis: The analysis and quantification of the spatio-temporal dynamics of the LULCC from 1999 to 2019 were achieved through Landsat image pre- processing, classification and post-processing. The general procedure in the pre-processing stage has include compositing, mosaicking (masking), the detection and restoration of bad lines, geometric rectification, radiometric calibration, atmospheric topographic correction using ArcGIS 10.1 and QGIS 2.8.1 [33]. Compositing refers to the process of combining spatially overlapping images into a single image based on an aggregation function whereas masking refers to the process of spatially assembling image datasets to produce a spatially continuous image. Six spectral bands of TM (band 1-5 and 7) and eight spectral bands of Landsat 8 OLI (bands 1-7 and 9) were used for image processing.

Supervised classification method using maximum likelihood classifier was used to classify each pixel based on the known ground objects using ArcGIS 10.1 [7, 16, 32]. Maximum likelihood algorithm (MLC) is one of the most popular supervised classification methods used with remote sensing image data [26]. The procedures used for image classification was as follows. The primary step was selecting training sites [34]. Polygon sampling method was used to sample the training sites from the processed images as it allowed the drawing of polygons for a particular spectral class. Different combinations of bands, image enhancement and color compositions were used to discriminate and interpret the surface features of the images during the process. Band combinations were selected based on the applicability of each band as each band have a set of a data file for a specific portion of the electromagnetic spectrum in identifying the features of the study. The extracted signatures from the samples were evaluated using the histogram technique and different trials were taken until unimodal distribution was achieved. Then after, signatures of the same class were merged by selecting all the signatures of each class. The supervised classification used the merged signature for the land cover map production [16, 32]. The training data set were used for generating class signatures and for classification of the whole image into meaningful information classes.

With regard to land use/land cover change analysis, once the land cover classifications were derived, ArcGIS 10.1 was used to prepare the land use land cover maps of 1999, 2009 and 2019 [35]. Then, the areas of the land use land cover (LULC) classes were calculated from the maps and analysis of LULCC and rates of changes were computed (Equ 2). Total LULCC between the three periods (1999, 2009 and 2019) were calculated as follows [16].

$$\text{Total LULC Gain/loss} = \text{Area of the final year} - \text{Area of the initial year} \quad (1)$$

$$\text{Percentage of LULC Gain/loss} = \frac{(\text{Area of the year - Area of the initial year})}{\text{Total area of the study area}} \quad (2)$$

LULCC matrix was developed by ArcGIS 10.1 to analyze the LULCC inter-category transitions and examined the buffer zone experience in LULCC transitions. The matrix was developed for the 1999-2009 and 2009-2019 transitions. Through the matrix, the area of gains, losses and persistence between the land use land cover types was calculated.

Accuracy Assessment: An error matrix was created for accuracy assessment to measure the quality of the information derived from remotely sensed data. It was performed by comparing the results created by remote sensing analysis to a reference / ground truth data for selected sample points [36]. About 240 random points were generated to yield random x, y coordinates within the study area using ArcGIS 10.1 and the random points were converted to KML and exported to Google Earth to provide detailed assessment of the agreement between the classified results and reference data, with the information of how the misclassification happened [35]. For accuracy valuation, overall classification accuracy and Kappa coefficient were calculated from the error matrix [36-38]. Overall classification accuracy was computed as the total number of correctly classified pixels divided by the total number of sample points. Kappa coefficient is a measure of overall statistical agreement of an error matrix, which takes non-diagonal elements into account. Kappa analysis is recognized as a powerful method for evaluating a single error matrix for it indicates the probability of correct classification after removing the probability of accidentally correct classification. Normally Kappa coefficients lie between 0 and 1, on the other hand kappa value characteristics of values from 0.4-0.60, 0.61-0.80 and 0.81-0.99 denote moderate, substantial and strong agreement respectively whereas value below 0.4 represents poor agreement [39].

Socio-Economic Data Analysis: Descriptive statistics of simple frequency analyses were used using SPSS (version 20) to describe ranking response of respondents on cause of the land use/land cover changes. Data collected through FGD and KII were analyzed qualitatively. Qualitative data analysis involved both thematic and content analysis based on how the results related to the research questions. Content analysis was used to edit qualitative data and reorganize it into meaningful shorter sentences. Thematic analysis was used to organize data into themes and codes were identified. After data collection, information of same category by giving emphasis for the past and current situations of LULCC and its causes were assembled and their similarity with the quantitative data created after which a report was written.

RESULTS

Land Use Cover: Land use land cover classification for the years1999, 2009 and 2019 are shown in Figure 3. Dense miombo woodlands are mainly found in the western and southern part of the park, while Agricultural land are found in the north east, North West and south eastern part of the park. Shrub land were more covers eastern part of the area. Waterbodies are found in the south western part of the site.

Accuracy Assessment: The confusion error matrix and Kappa statistics used for classification accuracy of 1999, 2009 and 2019 LULCC are presented in Table 3. The overall accuracy for 1999, 2009 and 2019 were 90%, 90% and 91% respectively. The Kappa statistics were 0.87, 0.88 and 0.89 for 1999, 2009 and 2019 respectively. Kappa statistics showed a strong agreement between classification result and reference values of land use land cover location. The recommended accuracies for the classification should be ≥ 85% [40].

Land Uses Land-Cover Inter-Category Transitions and Changes Trajectories in Gile Np Buffer Zone: Land use and land cover classification of Gile National Park buffer zone from 1999 to 2019 are summarized in Table 4 and graphically the distribution of LULCC over in 20 years is shown in Figure 4. The areas are arranged by year and land use categories as of 1999, 2009 and 2019. Dense miombo woodland and open miombo woodland are the most dominant land cover classes, covering 66, 555.99 and 44, 190.09 ha in 1999 respectively, which represents about 43.61 and 28.95% of the total land use. In the same year area coverage of agricultural land was 19, 517.13ha which was about 12.79 % of the total land cover.

A change matrix between 1999 and 2019 were produced by post-classification comparison from the classification results, which yield "from-to" change information identifying where and how much, change has occurred (Appendix 1). Of the total land use land cover about 34.57 and 40.86 % of land covers remained unchanged for 1999 to 2009 and 2009 to 2019 respectively, as the values reported along the diagonal written in bold express the unchanged area or persistence and shown on Figure 5.

Concerning net persistence, the ratio of the net change (gain–loss) to diagonals of each class, water bodies have shown the highest net change to persistence ratio during throughout the study period (1999-2019). The highest net change to persistence ratio implies the lowest persisting class of the land use land cover, so in this regard the lowest persisting land use land cover class in the buffer zone of Gile NP was water body followed by shrub land. From 2009-2019. dense miombo woodland and open miombo woodland showed the highest persisting land use land cover class (Appendix 1).

Forest (Miombo Woodland) Loss: Miombo woodland loss and its deforestation rate in the buffer zone of Gile NP from 1999 to 2019 at three- decade intervals showed an increment. In 1999, forested land (dense miombo woodland, open miombo woodland and shrub land) were estimated as128, 184.75ha which was about 83.98 % of total area on Gile NP buffer zone. Since then, the dense miombo woodland has decreased by 30, 890.16 ha between 1999 and 2009, which means that 20.24 % of 1999 dense miombo woodland has changed to other land uses and it was decreased by 8, 232.03ha from 2009 to 2019, which means that 5.39 % of 2009 dense miombo woodland has changed to other land uses within ten years. Within 20 years or the study period dense miombo woodland was decreased by 22, 658.1 ha, which tell us that 14.85 % of 1999 dense Miombo woodland has been changed to other land uses. The rate of forest loss (miombo woodlands) for the entire study period (1999-2019) was 1, 237.14ha/yr.

The highest annual rate of deforestation (4.05%) recorded from 1999 to 2009. Agricultural land expanded at the buffer zone of Gile NP from 1999 to 2019 by 3868.29 ha representing 16 % of 1999 agricultural land cover and this expansion was from clearing forest land (Table 4). In the buffer zone of Gile NP, major tracts of land have been cleared in the last decade due to slash-and-burn agriculture and significant population growth. Much of this forest has been dense and open miombo wood lands [28, 40]. Small frontier farmers living on the edge of forests drive much of the developing world's deforestation by cutting down forests for expanding agricultural land and settlement [15, 30]. Most land conversion from natural states to human uses is happening in the developing world, where population growth is most prevalent. The case of Gile NP buffer zone also verify this situation. Data about agricultural land size during 1999, 2009 and 2019 is described in (Appendix 2).

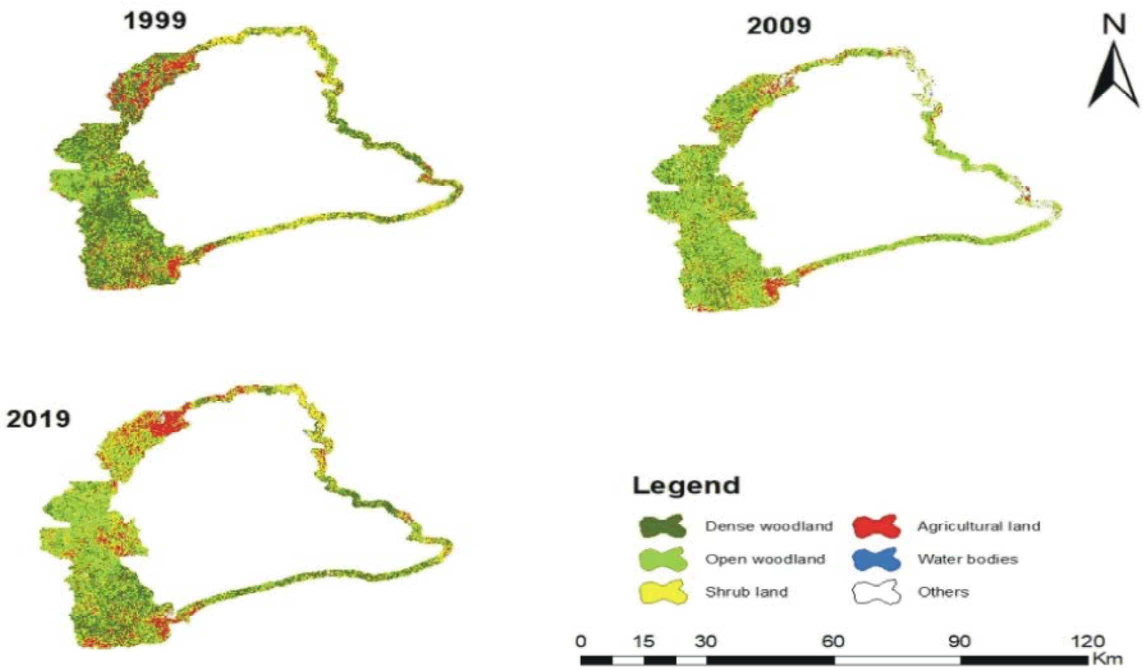

Fig 3: Land use land cover map of Gile NP Buffer zone in 1999, 2009 and 2019

Table 3: Accuracy of land use/land cover maps for 1999, 2009 and 2019

Years	LULC	DMWL	OMWL	SL	AL	WB	OT	Actual Sum	UA (%)	K
1999	DMWL	53	1	2	1	1	1	59	90	0.87
	OMWL	2	42	1	1	1	0	47	89	
	SL	0	2	34	1	1	0	38	89	
	AL	1	1	0	31	0	1	34	91	
	WB	0	1	1	0	30	2	34	88	
	OT	1	1	0	1	0	25	28	89	
	Actual sum	57	48	38	35	33	29	240		
	PA (%)	93	88	89	89	91	86			
Years	LULC	DMWL	OMWL	SL	AL	WB	OT	Actual sum	UA (%)	K
2009	DMWL	52	2	2	1	0	0	57	91	0.88
	OMWL	2	46	1	0	1	1	51	90	
	SL	1	0	36	0	2	1	40	90	
	AL	1	2	0	34	1	0	38	89	
	WB	0	1	0	2	25	1	29	86	
	OT	0	0	1	1	0	23	25	92	
	Actual sum	56	51	40	38	29	26	240		
	PA (%)	93	90	90	89	86	88			
Years	LULC	DMWL	OMWL	SL	AL	WB	OT	Actual sum	UA (%)	K
2019	DMWL	48	2	0	1	1	1	53	91	0.89
	OMWL	0	45	1	1	0	2	49	92	
	SL	1	0	32	1	0	0	34	94	
	AL	0	0	2	36	0	1	39	92	
	WB	1	1	0	1	26	1	30	87	
	OT	1	2	0	0	1	31	35	89	
	Actual sum	51	50	35	40	28	36	240		
	PA (%)	94	90	91	90	93	86			

DMWL-Dense Miombo Woodland, OMWL-Open Miombo Woodland, SL-Shrub Land, AL-Agricultural Land, WB-Water Body, OT-Others, UA-User's Accuracy, PA-Producer's Accuracy, K-Kappa Statistics.

Table 4: Land use land class area coverage, status and changes between 1999, 2009 and 2019 in ha and percent

	Area						Change (Gain/Loss)					
	1999		2009		2019		1999-2009		2009-2019		1999-2019	
LULC class	ha	%	Ha	%	ha	%	ha	%	ha	%	ha	%
DMWL	66555.99	43.61	35665.83	23.37	43897.86	28.76	-30890.16	-20.24	8232.03	5.39	-22658.1	-14.85
OMWL	44190.09	28.95	83032.74	54.40	62700.12	41.08	38842.65	25.45	-44190.09	-28.95	18510.03	12.13
SL	17438.67	11.43	4487.67	2.94	18493.92	12.12	-12951.00	-8.49	14006.25	9.18	1055.25	0.69
AL	19517.13	12.79	14681.61	9.62	23385.42	15.32	-4835.52	-3.17	8703.81	5.70	3868.29	2.53
WB	3295.44	2.16	410.31	0.27	237.6	0.16	-2885.13	-1.89	-172.71	-0.11	-3057.84	-2.00
OT	1633.32	1.07	14352.48	9.40	3915.72	2.57	12719.16	8.33	-10436.76	-6.84	2282.4	1.50
Total	152630.64	100	152630.64	100	152630.64	100						

DMWL-Dense Miombo Woodland, OMWL-Open Miombo Woodland, SL-Shrub Land, AL-Agricultural Land, WB-Water Body, OT-Others, Negative (-) indicates extreme loss

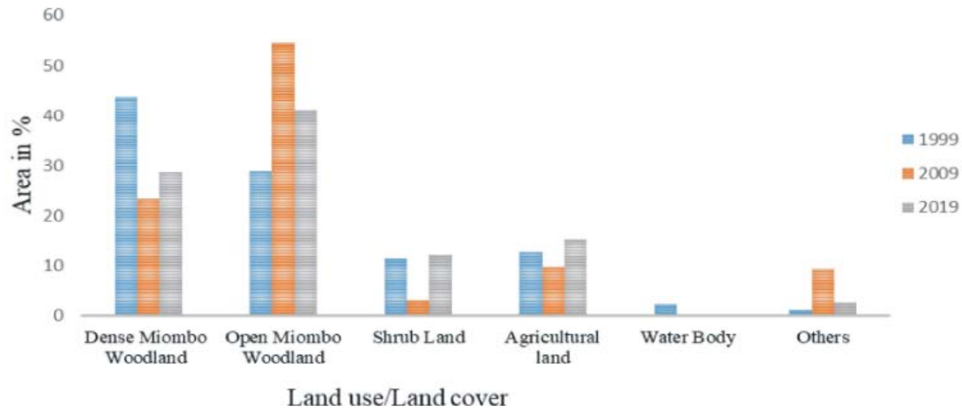

Fig. 4: Land use /land cover distribution at Gile NP buffer zone

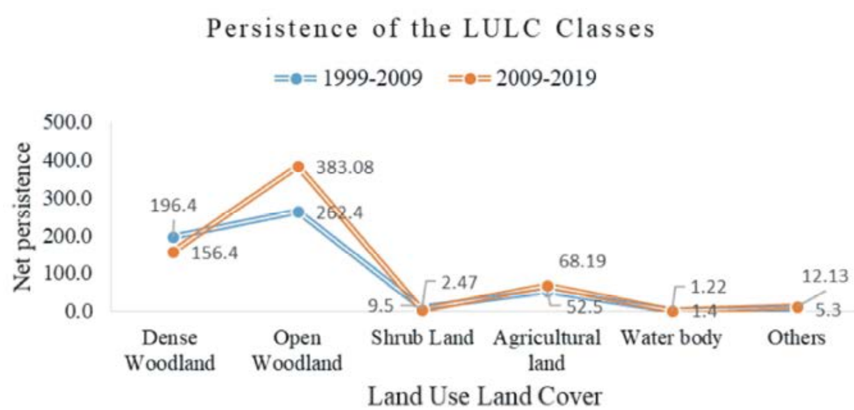

Fig. 5: Persistence (Unchanged) land use land cover classes

Cause of Land Use/Land Cover Change: A total of five causes were identified and reported by the respondents (N = 200) as being important cause of LULC changes in the study area. However, there were variations about each causes to which the local people viewed as cause for the LULC changes. In particular, almost all respondents reported all the listed causes play their own role for the problem of LULC change to be happen, however they ranked looking for fertile Agricultural land and new settlement as the first and second main cause of LULC changes respectively (Table 5). The population of the Mozambique has increased from17, 244, 188 in 1999 to 29, 496, 004 in 2019. Indicating an increase of 41.54 % during the period (1999 to 2019). A similar trend has also been observed in the area cover of agricultural land were expanded from area that existed in 1999 (Appendix 2).

Table 5: Cause of LULCC ranking in order of influence with 1 being the most influential cause

Cause of LULCC	Numbers	Mean	Std.Dev	Rank
Looking for Fertile Agricultural Land	195	1.06	0.426	1
Settlement	180	3.00	0.413	2
Fire	166	3.08	0.533	3
Awareness Gap	117	3.15	1.430	4
Illegal Logging	115	3.80	1.451	5

Table 6: Cause of LULCC Ranking based on Response of KIIs and FGDs

Cause Of LULCC	Percent %	Rank
Slash and Burn Agriculture	42.5	1
Settlement	25	2
Forest Concession	15	3
Weak Environmental Considerations	10	4
Fire	7.5	5

The results of FGDs, KIIs and field observation showed that anthropogenic activities were the predominant and immediate causes of LULCC in the study area. From a range of different causes, respondents perceived five human-related activities as major cause of LULCC (Table 6). The ranks are derived based on how the variables were selected frequently by the respondents.

Responses from KIIs and FGDs showed that slash and burn agriculture, settlement and forest concessions were among the major socio-economic and institutional causes of LULCC. Community in the area were based on slash and burn agriculture system to produce crops. Following population growth, new settlement were created in many areas of the buffer zone. According to KIIs and FGDs concession holders around Gile NP were posing a serious pressure on Gile NP buffer zone forest cover, hence they already finished theirs, they get log and wood from Gile NP buffer zone. This can be directly a main cause for LULCC and also by favoring conditions for farmers to open new farm land following forest degradation caused can indirectly cause of LULCC in the study area.

Group discussions with the community and Key informants on how slash and burn agriculture, the forest concession (timber and wood products) and settlements caused LULCC were summarized as follows:

Group member's mentioned that the only way community gets access to agricultural land when the needs to expand and want to have new land is through Slash and burn agriculture. They said that young farmers who grew in the area also get access of land by clearing forest land. This all poses pressure on forest land and responsible for LULCC in the area.

Previously Concession holders surrounding the buffer zone were used their wood for timber production, but after certain year they already finished theirs and started to do illegal logging in the buffer zone, Then, those who have got chance to sell log to them also started doing illegal logging, meanwhile attract peoples of the area to expand such activity and create competition among concession holders to log the wood illegally and finally it created LULCC.

Regarding settlement, "they said that free areas which have been created due to illegal logging attracted people's to settle there as a new settlement for looking new agricultural land. About weak environmental considerations, they said that, there was shortage of awareness creation about conservation of forest and sustainable use of the forest, there is no attempt from the side of government to encourage the community's participation on plantation forest. They said that fire is the least cause as compared to the other causes, because the impact of fire was mostly happened following the happening of the other causes".

DISCUSSION

Land use land cover analysis of Gile NP buffer zone over 20 years (1999-2019) revealed a dramatic change (Figure 3 and Table 4). Dense miombo woodland are continuously decreasing, with the highest rate in recent years. In1999 dense miombo woodland coverage of the area was relatively in good position as compared to its coverage of 2019 which showed decrement by 14.85 percent. But open miombo woodland and shrub land showed increment in size from its coverage from 1999 to 2019 by 12.13 and 0.69 percent respectively. Open miombo woodland is a transition state between dense miombo woodland and the other land use class like agricultural land and shrub land and the reverse is also true (from agriculture and other land use type to dense miombo woodland) that is why the area coverage for this land use class showed increment. Classifying shrub land as a distinct subclass in this study is based upon the local context of land use changes. Food and Agriculture Organization (FAO) guidelines generalize land cover to forest, other wooded land and other land uses in monitoring the world's forests through the Forest Resources Assessment Program [41, 42]. Here, shrub land is categorized as a sub-class of other wooded land, which refers to land not classified as "forest" an area that has only a sparse tree.

Area covered by water bodies in the study area shows decrement from its position of 1999. Its area coverage in 1999 represents 2.16 percent of the total land use class of the area, however by 2019 within 20 years it decreased to 0.16 % of total land use class of the area (buffer zone). Other land use types which include settlements, bare areas, rocky substance and roads according to this study increased from its coverage within 20 years by 2.57 %. The result showed that most of the conversion during this period were from dense miombo woodland to open miombo woodland, others land use class and agricultural land proportionally. This kind of scenario is the likely implication of slash and burn agriculture and logging of large trees from the dense and open miombo woodland for livelihood demands by community and concession holders. It was also confirmed during the FGDs that Slash and burn agriculture was a tradition of the native peoples and now a day there is serious competition on illegal logging between concession holders and community in the study area.

The temporal rate and spatial extent of forest loss were largely affected by expansion of agricultural land, population increment and climate change [43]. In general, areas of high population growth have experienced high forest loss over the years [31]. Population growth has increased demand for agricultural land and firewood energy and rural poverty restricts the ability to invest in sustainable land use practices. Population of Mozambique increased by 32.77% from 1999 to 2009 and 28.83 % from 2009 to 2018 [31] (Table 5). That is why growth of population exerted high pressure on the forest resources in order to derive people's livelihoods, higher population makes land for settlement and agriculture inadequate and consequently resort to the forest land (Appendix 2). The need of agricultural land expansion following population growth and climate change problem, forces community for looking new agricultural land which they directly/indirectly accessed by clearing forest. Increased agricultural land to forest land without proper management practices potentially have increased the vulnerability of the land to erosion and sedimentation in water bodies which plays significant role in LULCC and deforestation to be happen.

The present study has also shown that continued new settlements, expansion of agricultural land illegal logging by forest concession holders and shortage of information about natural resource management has accelerated land use land cover change in the study area. These situation (illegal logging by concession holders and illegal loggers who sale to concession holders) forced community to compete on the left over forest instead of conserving. Similarly, population growth and demand for agricultural land expansion were associated with biophysical degradations like soil productivity, water and environment. Equally important to the environmental problem, socio-economic and institutional problems were also posed a significant impact on the miombo woodland's sustainability in buffer zone of the park and generally the adverse impacts of LULCC were associated with the underlying factors related to human activities. Cause of LULCC related to slash and burn agriculture in the study area is linked to looking for fertile and productive land according to response from the housholds.it also linked with absence of alternative source of income and luck of awareness on diversification of source of income and in the study area.

The study area was once in good position of forest cover [28] and described by the FGDs and key informants as shown in LULC maps (Figure 3). Studies conducted in different parts of the Africa also reported similar results. For example, [43, 44] confirm that resources exploitation, agriculture, population growth, built-up, are considered as main carriers landscape change in north-western Rwanda and North Eastern Namibia respectively. The result of this finding was also in agreement with [19] who showed that vegetation reduced by about 41.67%, in Quirimbas National Park, Northern Mozambique due to population growth and agricultural expansion. It also in agreement with [45] who found that currently, the periphery and the buffer zone of the Gile national reserve are subject to strong and growing anthropogenic pressures, due mainly to a significant demographic growth and to slash-and-burn agriculture practices. Similar impacts of investment activities on forest (concession holders)on land use land cover change were reported in Ethiopia [46].

CONCLUSION

As revealed in the present study, land use/land cover change severely threatened miombo woodland in the study area. The quantitative spatio-temporal evidence obtained through interpretations of satellite images shows that Buffer zone of Gile NP has undergone significant LULCC since 1999. Between 1999 and 2019, the spatial distribution of LULCC shows a continuous expansion of agriculture and a reduction of miombo woodland and water bodies. The transition matrix developed to assess inter-category transitions and the change trajectories highlight the dominant dynamic events and internal conversions between LULC classes. Most of the change takes place in this study area were from dense miombo woodland to open miombo woodland and finally to the other identified land use class like agricultural land, shrub land and other land use type (settlement, bare land). Uncontrolled expansion of agricultural land and unsustainable exploitation of woodland due to population growth as well as presence of forest concession holders in the area were indeed the major causes of land use land cover change in the study area. The adverse impacts of LULCC were associated with the underlying factors related to human activities. Luck of awareness creation together with settlement and earning income from illegal logging have reduced forest land.

Recommendation: The qualitative and quantitative study of the LULCC, its driving forces and the impacts presented in this study could help a decision-maker by providing information that supports integrated park and its buffer zone management and future developments. Special attention should be given to restoration of degraded lands and to protect the natural resource in the park. The park and local agricultural organization should work on developing and expanding nursery site to establish seedling for using for restoration and even for market with collaboration of local community. Government also give emphasize on monitoring, evaluating and reviewing forest concession in that area. The national park should create an opportunity through which local community in buffer zone get income apart from agriculture, most preferable which run in harmony with forest management like upgrading noon timber forest product, tourism industry and livestock production.

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APPENDIX

Appendix 1: Land cover transition matrix in Gile NP buffer zone, 1999 to 2019 (km^2)

To	2009	DMWL	OMWL	SL	AL	WB	OT	Total	Loss
From 1999	DMWL	196.37	369.39	23.64	34.76	0.47	40.71	665.33	468.97
	OMWL	89.39	262.44	7.91	38.72	0.83	42.46	441.75	-88.12
	SL	38.02	89.33	9.50	14.27	0.45	22.76	174.33	164.83
	AL	23.83	86.49	2.40	52.48	0.48	29.42	195.10	142.63
	WB	7.51	16.63	0.99	3.61	1.39	2.81	32.94	31.55
	OT	1.42	5.76	0.42	2.93	0.48	5.31	16.33	11.02
	Total	356.54	830.04	44.86	146.77	4.10	143.48	1525.79	
	Gain	160.17	567.60	35.36	94.29	2.71	138.17		
To	2019	DMWL	OMWL	SL	AL	WB	OT	Total	Loss
From 2009	DMWL	156.40	151.29	23.56	21.86	0.13	3.29	356.54	200.14
	OMWL	226.22	383.08	102.06	102.23	0.64	15.81	830.04	446.96
	SL	31.74	8.31	2.47	1.40	0.11	0.84	44.86	42.40
	AL	10.49	46.42	15.08	68.19	0.02	6.56	146.77	78.57
	WB	0.69	0.42	0.87	0.38	1.22	0.52	4.10	2.88
	OT	13.29	37.26	40.84	39.71	0.25	12.13	143.48	131.35
	Total	438.83	626.79	184.88	233.77	2.38	39.14	1525.79	
	Gains	282.43	243.70	182.41	165.58	1.16	27.02		

DMWL-dense woodland, OMWL-open woodland, SL-shrub land, AL-agricultural land, WB-water-body, OT-others

Appendix 2: Information about Population, agricultural expansion and Miombo wood lands

No	Items	Unit	Year		
			1999	2009	2019
1.	Population	Number	17, 244, 188	22, 894, 710	29, 496, 004
2.	Agricultural Land expansion	ha	19517.13	14681.61	23385.42
3.	Annual Change of Forest Area	ha	128184.8	123186.2	125091.9

Source: For population: (FAOSTAT_data_8-17-2020 for population data of the country and own calculation for Agricultural Land expansion and Annual Change of Forest Area of Gile NP buffer zone)

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