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LAND COVER CHANGE PREDICTION OF KARLAHI FOREST RESERVE FOR THE YEAR 2029, 2039 AND 2049.

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Abstract: The prediction analysis of Karlahi Forest Reserve cover was carried out and its aim at predicting the state of the forest reserve in the year 2029, 2039 and 2049. The Markov and the CA Markov approaches of remote sensing was adopted as the methodology for the analysis. The result of the analysis shows a little increase in woodland in the year 2029,2039 and 2049 at 17.99 Km^2, 18.14 Km^2 and 18.22 Km^2 respectively. The bare surface within the forest reserve reduces in reciprocal to the woodland and the shrubs do decrease as it regenerates in to woodland. The Adamawa State Ministry of Environment and Natural Resource Development has to effectively established a model to protect the flora and fauna within the reserve and new policy on reserve areas protection should be put in place.

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Keyword: Land Use, land cover, Markov, CA Markov, Woodland, Shrubs and Bare Surface

1. Introduction

Natural resources relevant to the existence of mankind are found in major forests around the world, these forest include among others the Miombo Woodland found across south-central Africa, running from Angola in the west to Tanzania to the east , Congo Basin Forest in Central Africa, Kinabalu National Park in Kinabalu Malysia, Daintree Rainforest in the northeast coast of Queensland Australia, Forest of the New Guinea in Oceania (Australasia ecozone), the Taiga Biome found across North America, Europe, and Asia to the southern border of the arctic tundra, Great Lakes-St. Lawrence in Canada, the Lacandow Jungle in Mexico, Sambisa Forest in Borno Nigeria, the Afi River Forest Reserve in Cross River State, Oba Hills Forest Reserve in Osun State and the Gashaka Gumti Nation Part across Adamawa and Taraba State. Most literature on the nature of forest have shown that forests found around the globe, serve as reserve which houses diverse species of plants and animals, for individual and industrial use (Green Global Travel, 2019). Drius, Carranza, Stanisci and Jones, (2016) noted that terrestrial ecosystems serve as sources and sinks for carbon. Their research underscored the impacts of land use and land cover changes on the global climate through carbon cycle. Furthermore, much larger impacts of land use/land cover changes on ecosystem in relation to biodiversity, soil degradation and the ability of ecological systems to support humans, were identified by numerous scholars (IPCC, (2019); Dibaba, Demissie and Miegel (2020); Liu, Yang, Xue et al (2021) and Samuel, Bashir and Zemba (2022) providing a threshold for understanding and predicting Land Use/Land Cover changes, particularly deforestation and forest degradation which are paramount to forest management, biodiversity and conservation is important. Recently, many studies have revealed that Land Use/Land Cover changes are driven by a myriad of intricate processes which include interventions at different spatial and temporal scales (Kushwaha et al., 2011; Roshan et. al, 2019). The understanding of the process of Land Use/Land Cover change has led to a shift in paradigm, from a view of the effect of human impacts on the environment as leading mostly to deterioration of earth system processes to emphasis on the potentials for ecological restoration through land management.

Land use/land cover (LULC) changes are major issues of global environmental change. The satellite remote sensing data with their repetitive nature, have proven useful in mapping land use/ land cover patterns and changes over time. Quantification of such varieties is possible through Remote Sensing and Geographic Information System (GIS) techniques even when resultant spatial datasets are of different scales (Sarma et al., 2001). Such fields have aided in interpreting the kinetics of human bodily processes in distance and time. Land use refers to man's actions. During the past millennium, humans have adopted an increasingly big part in the modification of the planetary environment. With increase in number of growing technologies, man has emerged the major, most potent, and universal instrument of environmental change in the biosphere today (Pandian et al., 2014).

Change detection is the process of identifying differences in the state of a feature or phenomenon by observing it at different times (Singh, 1989). Mapping and identifying land cover/land usage and land change is significant and the most widely researched topic using remote sensing, land usage has been applied extensively to derive a number of biophysical variables, such as vegetation index, biomass, and carbon content. Furthermore, land cover/land uses pattern to determine change in the underlying natural and/or social processes, thus providing important data for modeling and interpreting many different phenomena on the globe. Knowledge of solid ground cover/land usage and its change is critical to effective planning and management of natural resources. Reis (2008), used satellite imagery and GIS in the study title "Analyzing Land Use/Land Cover Changes Using Remote Sensing and GIS in Rize, North-East Turkey" Tools used were Landsat Multi-spectral Scanner (MSS) and Enhanced Thematic Mapper Plus (ETM+). Maximum likelihood classification and change detection using method of remote sensing. The researcher observed the time period of 1976-2000 that the area of agriculture was increased approximately and forest area was decreased with alarming rate of 60%. Mannan et al., (2019) adopt Remote Sensing techniques in ArcGIS 10.2 to analyst changes in biomass over a period of 10 years, the researcher adopted supervised image classification technique, which reveal increase in Settlement and agricultural land during the period, with decrease in Forest area an attribute to determine change in population leading to decrease/expansion of villages and city centers.

Clearing of forest is a major driver of global warming and climate change (IPCC 2019). Scholars around the globe opined those forests of the world are being intensely decreased or destroyed particularly in the tropics (Apan, 1999). Another driver of global warming and climate change is forest degradation. It is a significant cause of anthropogenic greenhouse gases emission and fossil fuel combustion which account for a greater part of the global carbon dioxide emission (IPCC, 2007; Erbough et al. 2017 and Richard and Alexender 2017

Recent studies have shown that deforestation and forest degradation increase continuously at a million hectares per annum (IPPC, 2019) with a 25% degraded area in the world (GEF, 2021: Richard and Michal 2021). Most changes in forest-based ecosystems are owed to conversion of the forest to farmlands or residential areas, although some studies show variance in forest area and forest/vegetation resources degradation. This difference in forest cover in different areas is due to adopting method of remote sensing which is used in these studies in monitoring the state of Karlahi Forest Reserve (KFR) and projecting changes in vegetation cover of the reserve (KFR).

2. Material and Methods

This study will be carried out in Karlahi Forest Reserve in Fufore Local Government Area of Adamawa State. The study will focus on the projection of the state of the forest reserve in 2019 to 2029, 2039 and 2049.

Location and Extent

Karlahi Forest reserve is situated in Fufore Local Government Area of Adamawa State. It is located between latitudes $8^0 49'30''$N and $9^0 00'$N, of the equator and longitudes $12^0 36'0''$E and $12^0 45'0''$E of the prime meridian. Its land area is estimated at about of 105.44 sq Km. Karlahi Forest Reserve is bounded by the Toja Stream to the North and Beti Stream to the South-to-South Eastern part (Figure 1).

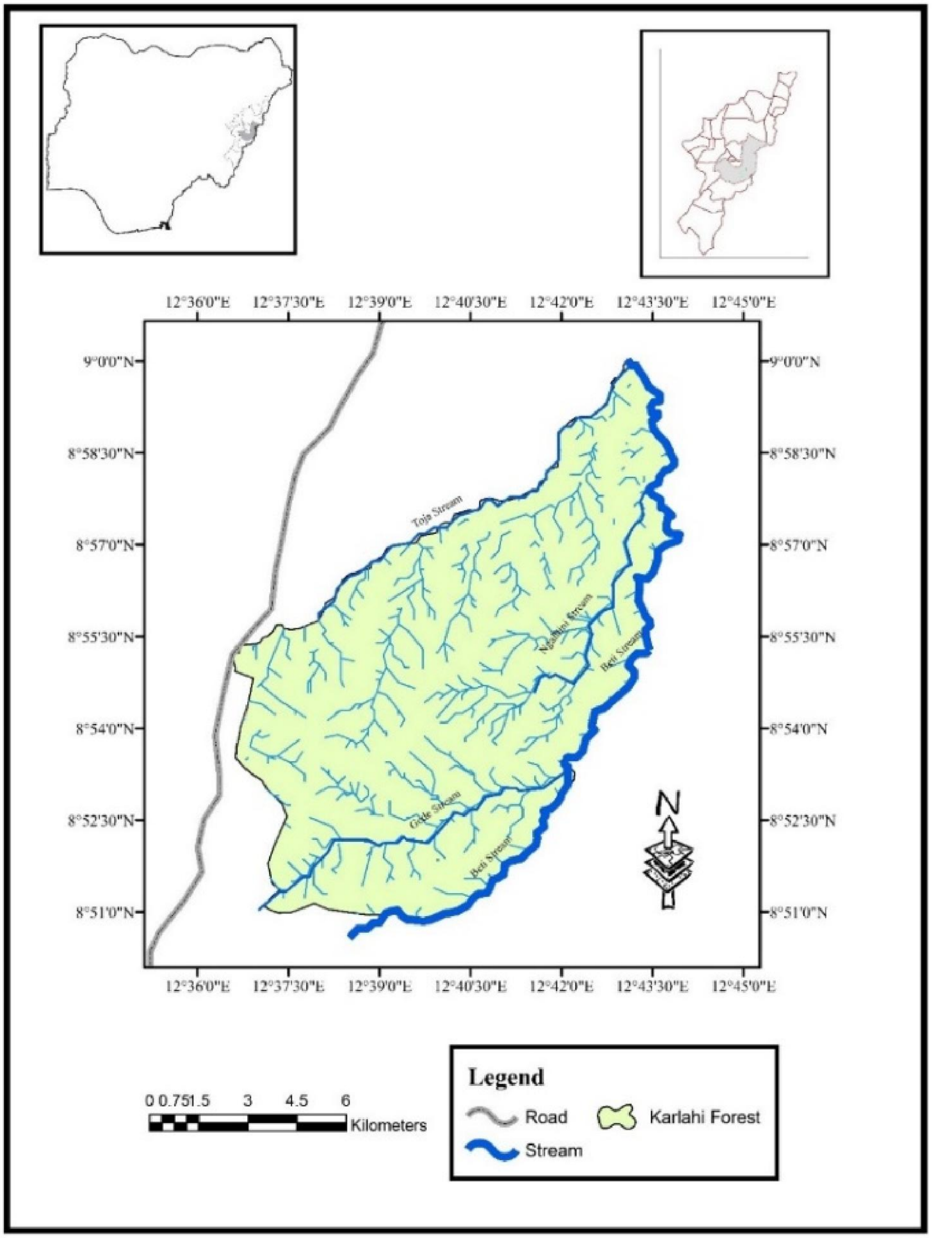

Figure 1: Study Area
Source: Researcher 2020

Land Use Change Modeling
Markov Chain Analysis

Markov chain model was used in this research to predict future changes by considering land cover classes derived from the satellite data and evaluating the future projection within a span of 3 decades (2019-2029, 2019-2039 and 2019-2049). A Markov process is one in which the state of a system at time B can be predicted by the state of the system at time A given a matrix of transition probabilities from each cover class to every other cover class. The MARKOV module can be used to create such a transition probability matrix. As input, it takes two land cover maps. It then produces the following outputs:

A transition probability matrix: The matrix is automatically displayed and saved by clicking ok on the IDRISI Silva module for Markov transition estimator after all required inputs have been entered (Earlier and later image, number of time period between the earlier and the later image and the time period needed to be projected) on the module as shown on Figure 2 using the image of 2008 and 2019 as an example.

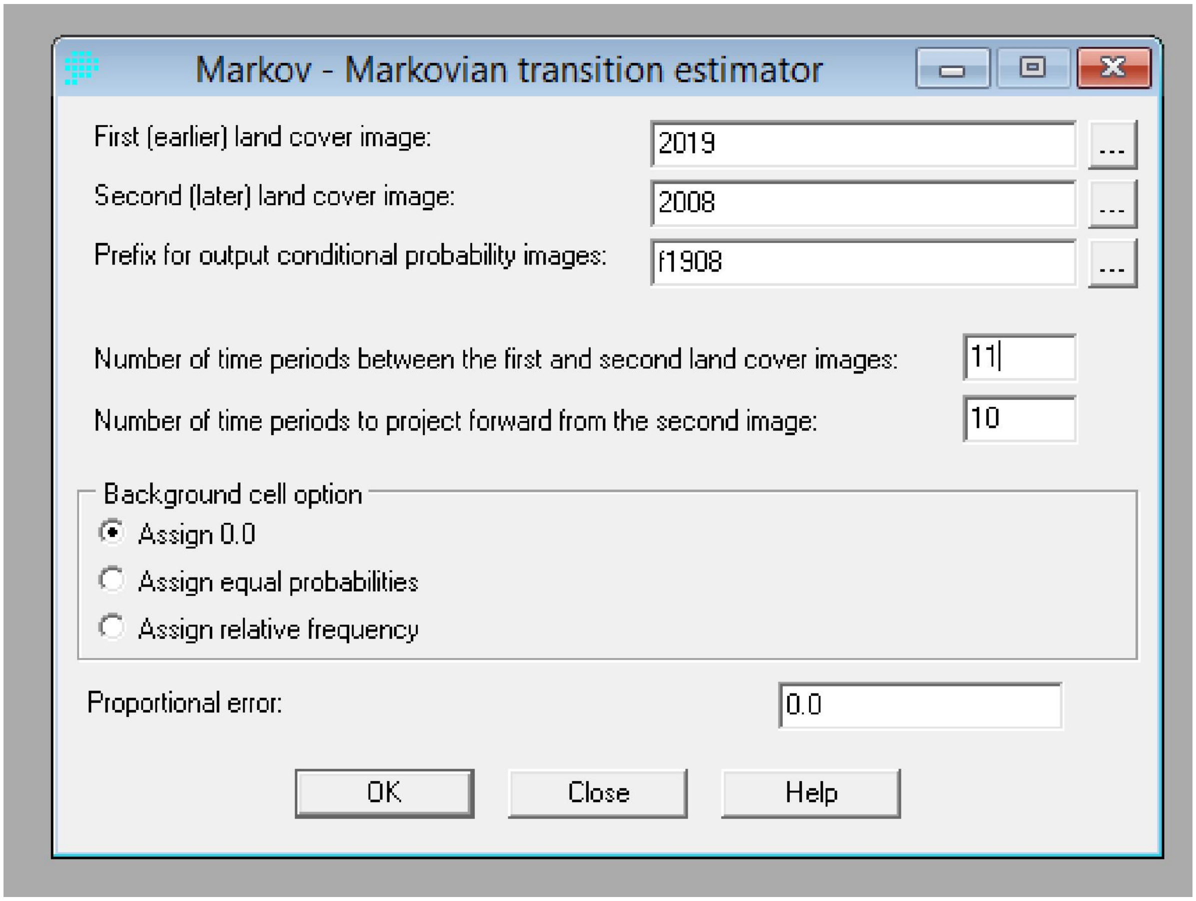

Figure 2: Markov transition Estimating

- Transition probabilities express the likelihood that a pixel of a given class will change to any other class (or stay the same) in the next time period.

• A transition areas matrix. this expresses the total area (in cells) expected to change in the next time period.

• A set of conditional probability images one for each land cover class (Woodland, Shrubs and Bare Surface). These maps express the probability that each pixel will belong to the designated class in the next time period. They are called conditional probability maps since this probability is conditional on their current state.

CA-Markov (Cellular Automata) for Forest Cover Change Projection

CA-Markov is a combined Cellular Automata / Markov Chain land cover prediction procedure that adds an element of spatial uniqueness of likely spatial distribution of transitions to Markov chain.

These Cellular Automata procedures in combination with Markov Chain analysis algorithm works as follows: The transition areas file from a Markov Chain analysis (using the Markov module) of a classified imageries of 2008 (earlier) and 2019 (later) image was used to established the quantity of expected land cover change from each existing woodland, shrubs and bare surface to each other category in the next projected period.

The baseline land cover image (the 2019 land cover class used in the Markov Chain analysis) was used as the beginning level for change simulation. This method has proven essential in ecological studies and it was used in forest cover monitoring, CA-Markov in projecting the state of the forest over the years (2029, 2039, 2049 and 2059).

3. Result

Karlahi Forest Reserve Projection (2029, 2039 and 2049)

The projected land cover types of 2029, 2039 and 2049 were computed using CA-Markov model and the area cover by the landcover classes were shown in Table 1

Table 1: 2029, 2039 and 2049 land cover areas

Land cover	2029	2039	2049
Woodland	17.99 (14.68%)	18.14(14.80%)	18.22 (14.87%)
Shrubs	10.82 (8.83%)	10.75 (8.77%)	10.71 (8.75%)
Bare Surfaces	93.71 (76.49%)	93.63 (76.42%)	93.58 (76.38%)

Table 1 shows a decrease in area cover by shrubs which are 8.83% in 2029 to 8.77% in 2039 and 8.75% in 2049 respectively and woodland also was projected to increases from 14.68% in 2029 to 14.80% in 2039 and 14.87% in 2049. the rate at which shrubs decreases and woodland increasing is in conferment with the present security challenges within the forest reserve as the increase in area cover by woodland is predominately found along the highland (KII 2020) and a bare surface decrease from 93.71 Km^2 in 2029 to 93.63 Km^2 in 2039 and 93.53 Km^2 in 2049 as shown in figure 3, 4 and 5.

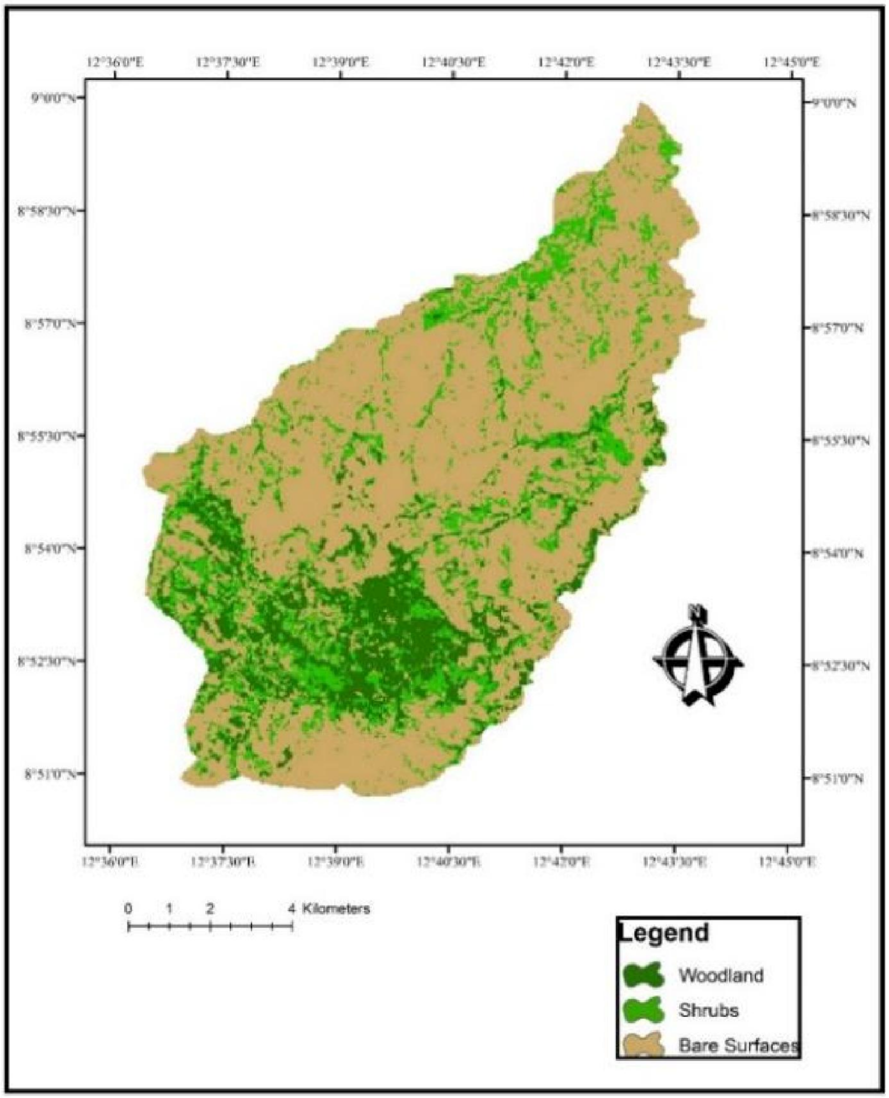

Figure 3: Karlahi Forest Reserve at 2029

Source: Researcher 2020

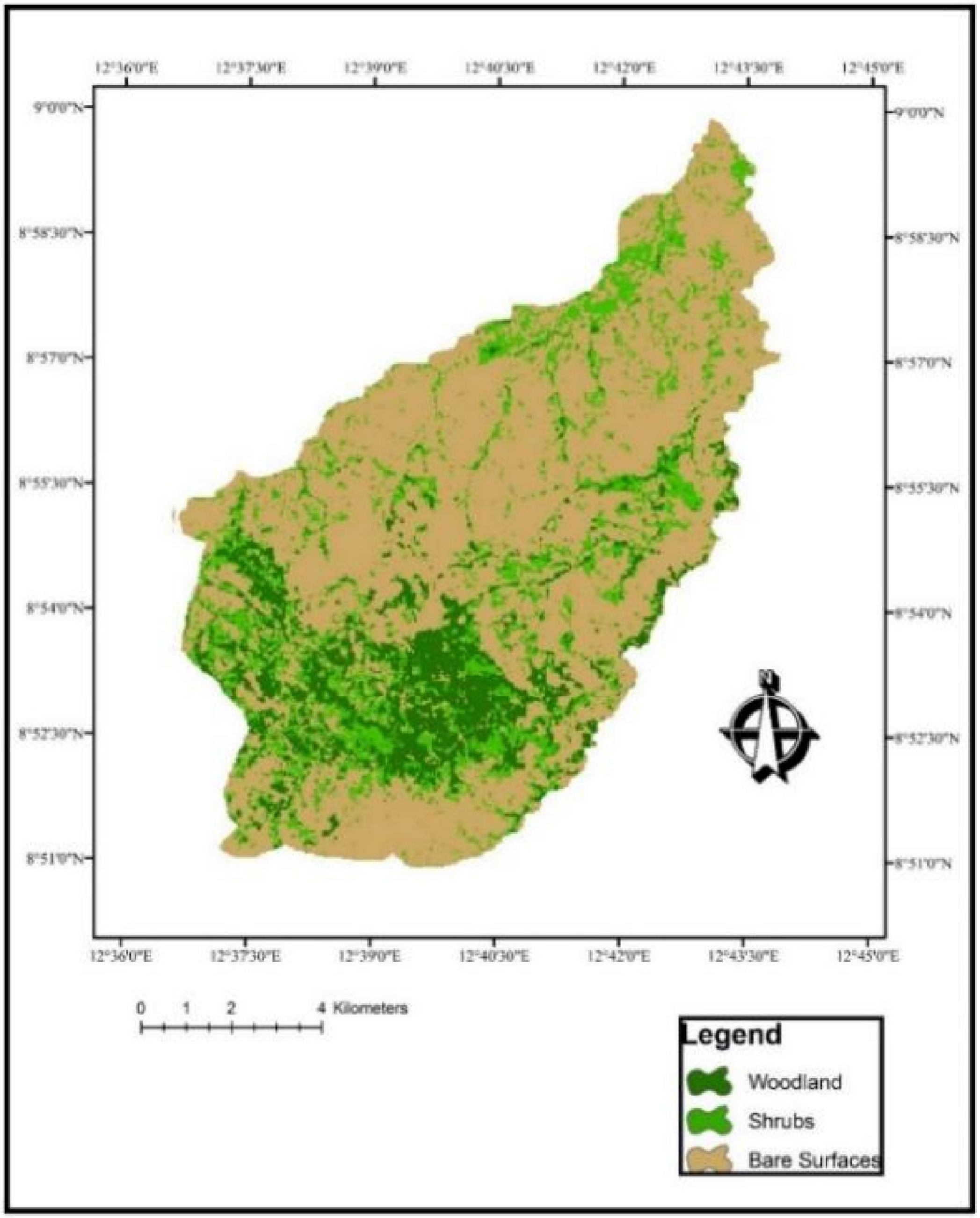

Figure 4: Karlahi Forest Reserve at 2039
Source: Researcher 2020

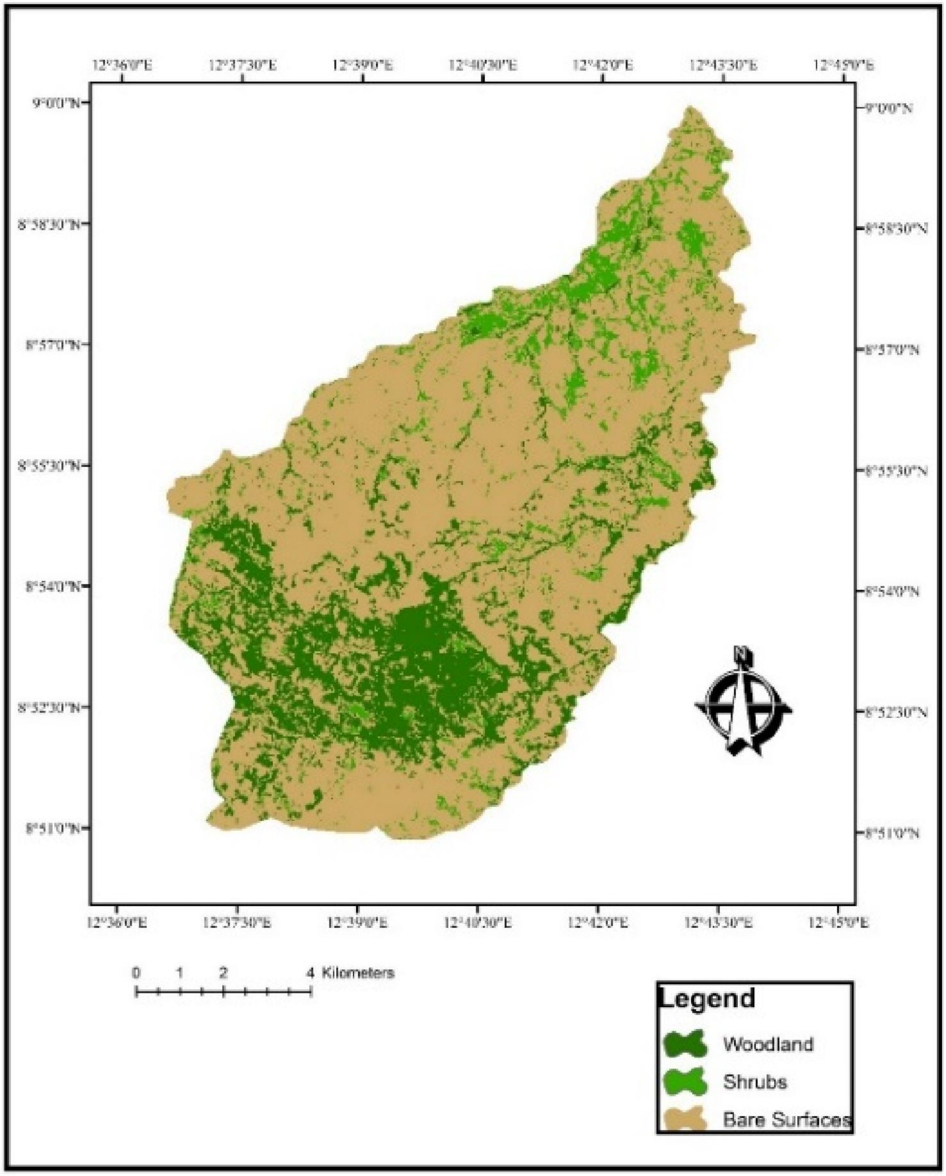

Figure 5: Karlahi Forest Reserve at 2049
Source: Researcher 2020.

Insecurity had become a major treat to so many activities in Nigeria but play a significant role in forest reserve conservation as Forestry Association of Nigeria (FAN) has recently lamented that insecurity in the country as one of the challenges confronting the forestry sector as no management activities can take place and forestry activities have been hindered in most of the northern region (Ladan 2014) and it result into area cleared by an anthropogenic activities regenerate to shrubs and area covered by shrubs is converted to woodland as shown in plate 1.

Plate 1: Forest Regeneration.

These changes in landcover classes as a result of this insecurity is shown clearly in Karlahi Forest Reserve as presented in table 2 and figure 6

Table 2: 1989 to 2049 land cover areas

	1989%	1999%	2008%	2019%	2029%	2039%	2049%
Woodland	77.4	55.6	24.3	18.8	14.68	14.80	14.87
Shrubs	18.4	13	14.6	8.2	8.83	8.77	8.75
Bare Surfaces	4.2	31.4	61.1	73	76.49	76.42	76.38

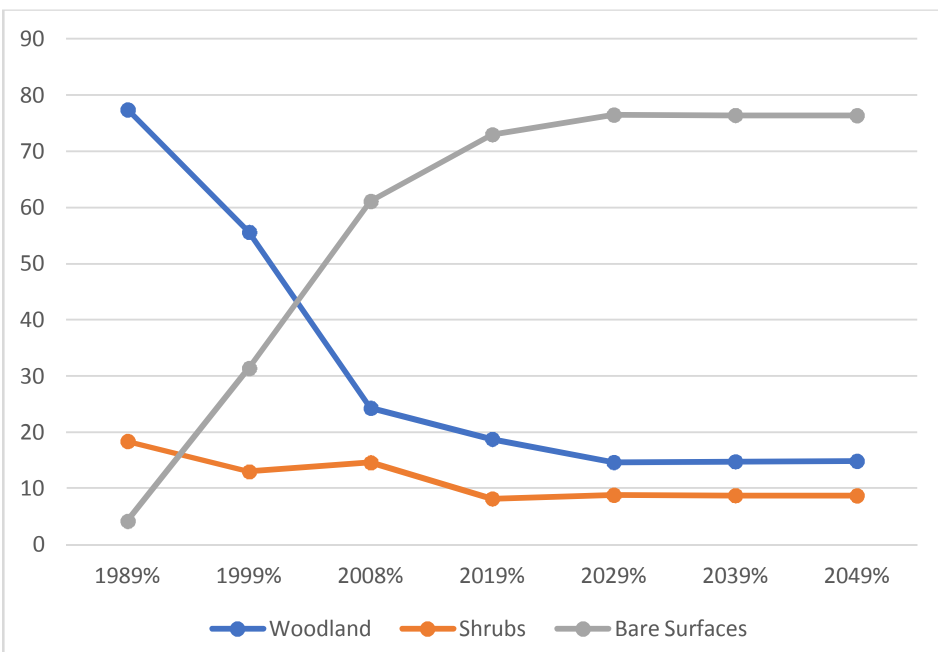

Figure 6: Trend in Land Cover Changes in Karlahi Forest Reserve (1989 to 2049)

The reduction in area coverage of bare surfaces and shrubs as shown in figure 5 is expected to continue as woodland increase and this will continue if the level of insecurity in and around the forest reserve continues thereby making people not to enter into the forest reserve for lumbering, firewood/ charcoal extraction and grazing.

A reduction in woodland cover from 1989 to 2019 (77.4%, 55.6%, 24.3% and 18.8%) as potray by Samuel, Bashir and Zemba (2022) were as a result of population increase and people settling within and around the forest reserve and depend on it for accommodation, cattle ranching, logging, cash crop farming and firewood/charcoal extraction but it differs with the changes in 2029-2049 as the state of insecurity in the country makes the forest home to criminals and hoodlums thereby, making people to exit the forest and looking for alternative places for farming, grazing and other anthropogenic activities which result to regeneration of the forestland and this became the major reason that the woodland is increasing on the projected land cover area of the projected years (2029-2049).

4. Conclusions

Front-line link with the current findings on this research, it was concluded that Karlahi Forest Reserve Landcovers changes drastically from 1989 to 2019 as bare surfaces is increasing rapidly and this increase in bare surface is attributed to fertile soil as notice in several studies. The issue of insecurity within the forest reserve in the recent years makes the forest to start regenerating as thereby making the woodland to start increasing and bare surface to decreasing.

5. Recommendations

The prediction study of the Karlahi Forest Reserve land cover reveals that the forest green area (Woodland and shrubs) will increase as a result of the present insecurity within the forest but in the event of the end of the insecurity within the forest the Adamawa State Ministry of Environment and Natural Resource Development should come up with a model to protect the flora and fauna within the reserve and a new policy on reserve areas protection should also be put in place.

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