

Assessment of some soils land cover changes in Gashaka Gumti National Park, Taraba State, Northeastern Nigeria

¹Musa, S. A., ¹Saddiq, A. M. and ²Abubakar, S.

¹Department of Soil Science Faculty of Agriculture, Modibbo Adama University, Yola

²National Agency for the Great Green Wall, Plot 102 Ebitu Ukiwe Street opposite Shoprite-Jabi Abuja

Paper History

Received: 20th Jun, 2024

Accepted: 21st July, 2024

Published: July, 2024

Abstract:

Land cover change has always had a central role in land change science. This central role is largely the result of the possibilities to map and characterize land cover based on observations and remote sensing. This paper argues that more attention should be given to land use and land functions and linkages between these. Consideration of land functions that provide a wide range of goods and services makes more integrated assessments of land change possible. The increasing attention to multifunctional land use is another incentive to develop methods to assess changes in land functions. The study was conducted in 2020 to evaluate land cover changes of some soils in Gashaka Gumti National Park (GGNP) Taraba State, North East Nigeria. Two hundred hectares (200ha) for GGNP were selected. Supervised system of classification were used, Before the pre-processing and classification of satellites imageries began, field survey was performed throughout the study area using Global Positioning System (GPS) equipment and a Canon EOS 3000D 18.0 MP Digital SLR Camera + 18-55mm EF-S f/3.5-5.6 Lens. The field survey was conducted in order to obtain accurate location for each land cover class, which was used in the classification scheme. Four land covers were identified on the ground; their coordinates was recorded and subsequently used to trace the same points on the images, these were then identified in the image as bare surface/Eroded land, Dense Vegetation, Water body/Wet land and Sparse Vegetation respectively. Administered image classification technique studies of 2010 to 2015 and 2010 to 2020 imageries indicated changes in land cover classes. The Bare surface/Eroded land and Dense Vegetation land cover land decreased in size by 7 and 29 percent, while Water body/Wetland and Sparse Vegetation cover increased in size by 26 and 47 percent respectively.

Corresponding author

Musa, S. A.

salihumam13@gmail.com

Keywords: Evaluation, Land Cover change, Gashaka Gumti National Park

1. Introduction

Land use and cover change have been identified as one of the prime determinants of global change with major impacts on ecosystems, global biogeochemistry, climate change and human vulnerability [1]. Up to the 1990s land use and land cover change were mainly studied from a disciplinary perspective. The need for interdisciplinary approaches to fully understand the interactions within the land system has, more recently, led to the emergence of the new interdisciplinary field of land change science [2, 3]. New tools and techniques, often based on the synergetic use of disciplinary theory and knowledge, have increased our ability to monitor and explore changes in land use and land cover. Advances in remote sensing and land inventory techniques enable land scientists to make an assessment of current land resources, identify ongoing land cover change processes and identify hot-spots of change [4]. New sensors provide increasing spatial detail, global datasets of land cover have become available [1, 5] and some regions with rapid ongoing land cover changes are monitored with high temporal resolution (e.g. the PRODES and DETER projects

in Brazil) [6]. Monitoring of land use and land cover change also includes local case studies in which the processes of change are studied from a sociologic and anthropogenic point of view providing insights in the local drivers and processes. Such case studies may be generalized in meta-analysis in order to identify common patterns and processes [7, 8]. Models have proven to be an important tool, both to conceptualize and test our understanding of the role of different drivers in land use and land cover change and to explore scenarios of possible future developments [9]. In communicating scientific understandings of land change to policy makers and other stakeholders scenarios of alternative trajectories of land change have become widely accepted [8]. A wide variety of land use and land cover change models have been developed to serve the different processes, scales of analysis and research questions [8]. While the simultaneous development of different modeling approaches has stimulated advances in modeling, most approaches are complementary and targeted at specific scales or issues. Levels of complexity range from models representing decision making of individual actors and actor

interactions to simple transition matrix extrapolations. In spite of the large progress in simulation and other data mining techniques, uncertainty levels remain high and the predictability of land use and land cover change in most instances equally remain low, indicating the need to further improve our understanding and characterization of land change [10]. One of the main challenges in monitoring, modeling and communicating land change is the relation between land cover, land use and the provision of goods and services by the land system. Many studies have assessed the consequences of land use and land cover change on different socio-economic and environmental conditions as a post-analysis or impact assessment, e.g. by a series of indicators [7]. However, in reality the functionality of the land is intricately linked to the land cover [11]. A change in the provision of goods and services by the land is often not just a result of land cover change but an important driving factor of future land cover dynamics as well. The Millennium Ecosystem Assessment has requested specific attention for the way in which land cover change and ecosystem

functioning are linked [12]. Such assessments are difficult because there is no one-to-one relation between land cover and functionality. The aim of the study is to investigate and analyze the current land cover changes in Gashaka Gumti National Park of Taraba State, Northeastern Nigeria, focusing on the impact of the changes on soil properties and their characteristics.

2. Material and methods

2.1 Location and Extent of the Study Area

The study area is Gashaka Gumti National Park (GGNP), Taraba State located between latitudes, 7° 28' and 12° 27' N, and longitudes 11° 31' and 21° 38' E within the Savannah woodland zone of Nigeria [13]. It lies at an elevation of 501.0912m above sea level, situated about 120km away from Jalingo the Capital city of Taraba State in the Northern Guinea Savanna Zone of Nigeria. Figure 1 shows Map of Gashaka Local Government area showing the study area.

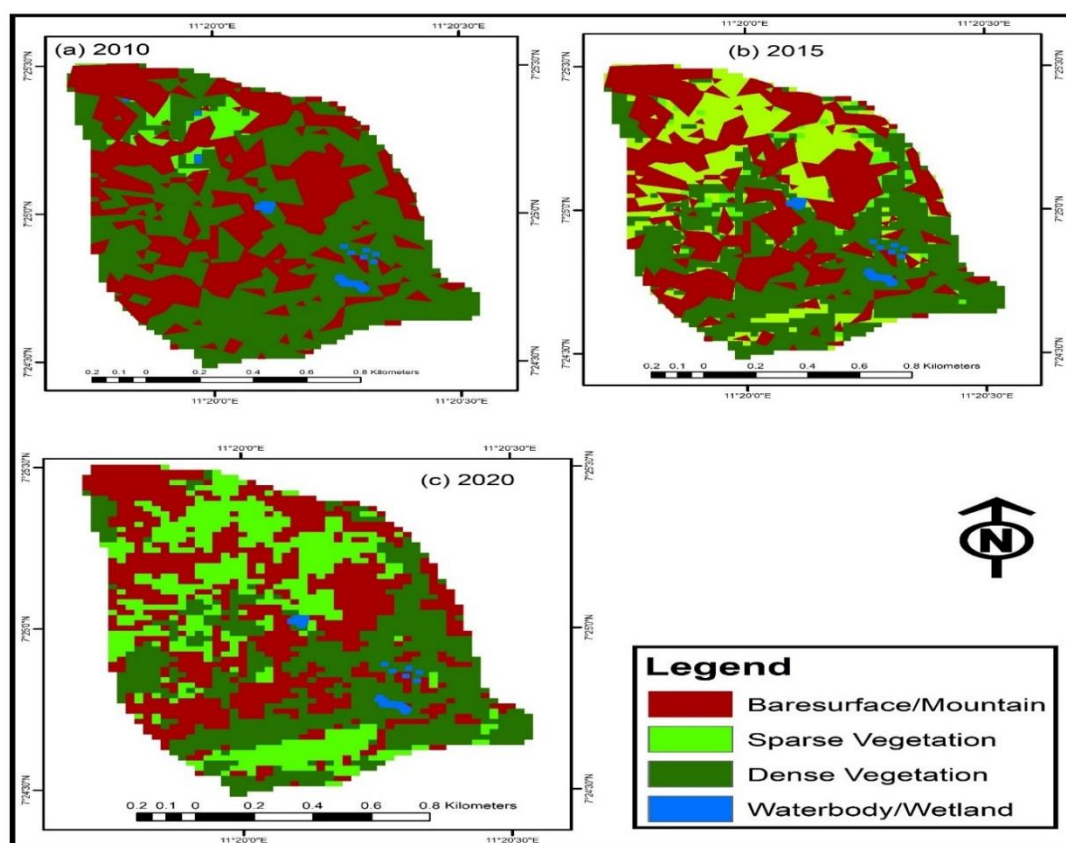


Figure 1: Classified Vegetation of Some Soils of Gashaka Gumti National Park (GGNP) "Between" 2010, 2015 and 2020

2.2 Climate

The area is characterized with dry and wet season, the rainy season begins in March or early April and ends in mid-November. Rainfall ranges from 1200mm in the North to 3000mm in the Southern part of the area [14]. The high rainfall is aided by the mountains of the area since humidity from the Atlantic is forced up into higher elevations, cools down and condenses to rain-bearing clouds. This, in turn allows the growth of moist forests.

Temperature ranged between 15.2 °C to 39°C and a mean temperature of about 33.3 °C and seasonal variation in relative humidity of 20-30% in January and March which increase to 80% from April to September [14].

2.3 Vegetation

Vegetation of Gashaka Gumti National park (GGNP) is characteristic of the Northern Guinea Savanna vegetation, comprising of short grasses interspersed with shrubs and

high woody trees with mountainous hills around some areas. Common among trees found on this area are Red flowered cotton tree: (*Bombax costatum*, *Grewia mollis* and *Gardenia aqualla*), African rose wood tree: (*Pterocarpus erinaceus* and *Sterculia setigera*), Counter wood, Senegal Annona, Cooling, Sweet plum, Rolfe (*Cassia siamea*), Palm tree (*Elaeis guineensis*) and Baobab tree (*Adansonia digitata*, *Moringa oleifera*, *Cola nitida* and *Lobelia colomnaries*) etc. [14].

2.4 Geology

The geology of the area is characterized by a basement complex area Heal basement complex, major rocks are gneiss, magmatites, and granite [15].

2.5 Geomorphology

Gashaka Gumti National Park has many rivers and lakes, Moyo Selbe Lake, Mayo Cams and Mayo Jarendi

2.6 Use of GPS and Ground Trothing

Supervised system of classification were used, Before the pre-processing and classification of satellites imageries began, field survey was performed throughout the study area using Global Positioning System (GPS) equipment and a Canon EOS 3000D 18.0 MP Digital SLR Camera + 18-55mm EF-S f/3.5-5.6 Lens. The field survey was conducted in order to obtain accurate location for each land cover class, which was used in the classification scheme. Various land covers were identified on the ground; their coordinates was

recorded and subsequently used to trace the same points on the images. These were then identified in the image as bare surface/Eroded land, Dense Vegetation, Water-body/Wetland and Sparse Vegetation for GGNP respectively. Field work exercises were conducted from March to April 2020. The field work was conducted so as to increase the researcher's understanding of the patterns and characters of land cover change of the study area during different seasons. Data were collected from different sites base on the different land cover type in the area. Each site was marked with the aid of GPS technology, as explained above to allow for further integration with the spatial data in Geographical Information System (GIS) and image classification system. In order to verify the selection of the land cover change type in the area. The GIS software was used include Integrated Land Water and Information System (ILWIS) (version 3.1, Arc GIS 9.3.1) and Earth Resources [16].

2.7 Data Analysis

GIS was used for the land cover changes analysis to indicate basic characteristics and significant different of soils of the study area.

3. Result and Discussion

Land cover changes of some soils in Gashaka Gumti national park from 2010 to 2020 are shown in Table 1. Table 1 and Figures 1 present land cover classes change from 2010, 2015 and 2020 of uncultivated soils.

Table 1: Assessment of Land cover Changes of Some Soils for Uncultivated Area From 2010, 2015 and 2020 using Satellites Imageries.

Year	2010	Percentage	2015	Percentage	2020	Percentage
Land cover Classes	Area (km ²)	(%)	Area (km ²)	(%)	Area (km ²)	(%)
Bare surface/Eroded land	159195.41	8.18	233076.16	11.97	21456.63	1.10
Dense Vegetation	1572846.60	80.81	977160.79	50.20	1005393.45	51.65
Water body/Wetland	3518.13	0.18	3125.00	0.16	515952.51	26.51
Sparse Vegetation	210845.65	10.83	733043.84	37.66	403603.20	20.74
Total area	1946405.79	100.00	1946405.79	100.00	1946405.79	100.00

The result indicates that in 2010 Bare surface/Eroded land covered an area of 159195.416km² (8.18%), while the land cover increased to 233076.16km² (11.97%) in 2015 and land cover further decreased to 21456.63km² (1.10%) In 2020. Dense Vegetation had 1572846.60km² (80.81%), in 2010 and in 2015 it decreased to 977160.79km² (50.20%) it further increased to 1005393.45km² (51.65%) in 2020. In 2010 Water body/Wet land had 3518.13km² (0.18%) and

decreased in 2015 to 3125.00km² (0.16%) it further increased to 515952.51 km² (26.51%) in 2020 as in Table 1. In 2010 Sparse Vegetation had 210845.65km² (10.83%) and increased in 2015 to 733043.84km² (37.66%) it further decreased to 403603.20 km² (20.74%) in 2020 as in Table 1. Difference in Land cover Change of Some Soils of GGNP between 2010 and 2015 in Percentage as in shown Table 2.

Table 2: Difference in Land cover Change of Some Soils on Gashaka Gumti National park "Between" 2010 and 2015 in Percentage.

Land cover Class	Area (km ²) 2010	Area (km ²) 2015	Difference	Percentage (%)	Remarks
Bare surface/Eroded land	159195.41	233076.16	+73880.75	3.795752683	Increased
Dense Vegetation	1572846.6	977160.79	-595685.81	-30.60439982	Decreased
Water body/Wetland	3518.13	3125.00	-393.13	-0.020197741	Decreased
Sparse Vegetation	210845.65	733043.84	+522198.19	26.82884487	Increased
Total Area					

There was an increase in land cover in Bare surface/Eroded land with a value of +73880.75km²

(3.796%), there was a decreased in Dense Vegetation (-595685.81km²; 30.604%) and that of Water body/Wet land

(-393.13km²; 0.0202%) recorded an decrease between 2010 and 2015 while that of Sparse vegetation

(+522198.19km²; 26.83%) recorded an increase between 2010 and 2015 are shown Table 3.

Table 3: Difference in Land cover Change of Some Soils on Gashaka Gumti National Park "Between" 2010 and 2020 in Percentage.

Land cover Classes	Area (km ²) 2010	Area (km ²) 2020	Difference	Percentage (%)	Remarks
Bare surface/Eroded land	159195.41	21456.63	-137738.78	7.076570606	Decreased
Dense Vegetation	1572846.6	1005393.45	-567453.15	29.15389755	Decreased
Water body/Wetland	3518.13	515952.51	+512434.38	26.32721207	Increased
Sparse Vegetation	210845.65	403603.2	+192757.55	47.75917287	Increased

Difference in Land cover Change of Some Soils of GGNP "between" 2010 and 2020 in Percentage (Table 3) there was an decrease in land cover in Bare surface/Eroded land with a value of (-137738.78km²; 7.07657%), there was a decreased in Dense Vegetation (-567453.15km²; 29.154%) and that of Water body/Wet land (+512434.38km²; 26.327%) recorded an increase between 2010 and 2020 while that of Sparse vegetation (+192757.55km²; 47.759%) recorded an increase between 2010 and 2020 are shown in (Table 3) respectively.

Four land cover classes were identified and studied. They include Bare surface/Eroded land, Dense Vegetation, water body/Wetland and Sparse Vegetation. Administered image classification technique studies of 2010 to 2015 and 2010 to 2020 imageries indicated changes in land cover classes. The Bare surface/Eroded land and Dense Vegetation decreased in size, while Water body/Wetland and Sparse Vegetation decreased in size are shown in Figure 2. The increased on water body/Wet land and Sparse Vegetation is attributed to cutting down of trees and local miming activities in the study area, the findings on rainfall and temperature pattern over the same period showed that there was decrease in the amount of rainfall and an increased in temperature.

The decrease in rainfall and slight increase in minimum and maximum temperatures could only bring about the regeneration and development of the vegetation as reported by Verburg, *et al.* [15] and Pontius, *et al.* [16]. Therefore, the decrease in sizes of the Bare surface/Erode land and Water body/Wet land may be attributed to land cover change and climatic factors, other factors like the anthropogenic activities which were observed from the study to be prevalent in some parts of the study area could have been responsible. This observation agrees with that of Guo [14] and Dunn [18] who investigated the effect of anthropogenic factors on wildlife resources and found them to be serious destroying factors.

Figures 2, 3, and 4 show that further classification techniques studies of the imageries and column charts between 2010 and 2015 revealed an increase in the size of both Bare surface/Erode land and sparse vegetation. The Dense vegetation and Water body/Wet land continued to decrease in size. The period of 2010 to 2020 (Figure 2 and column charts 3, 4 and 5) revealed that Bare surface/Erode land and dense vegetation decrease in size and that of Water body/Wetland and Sparse vegetation increase in size.

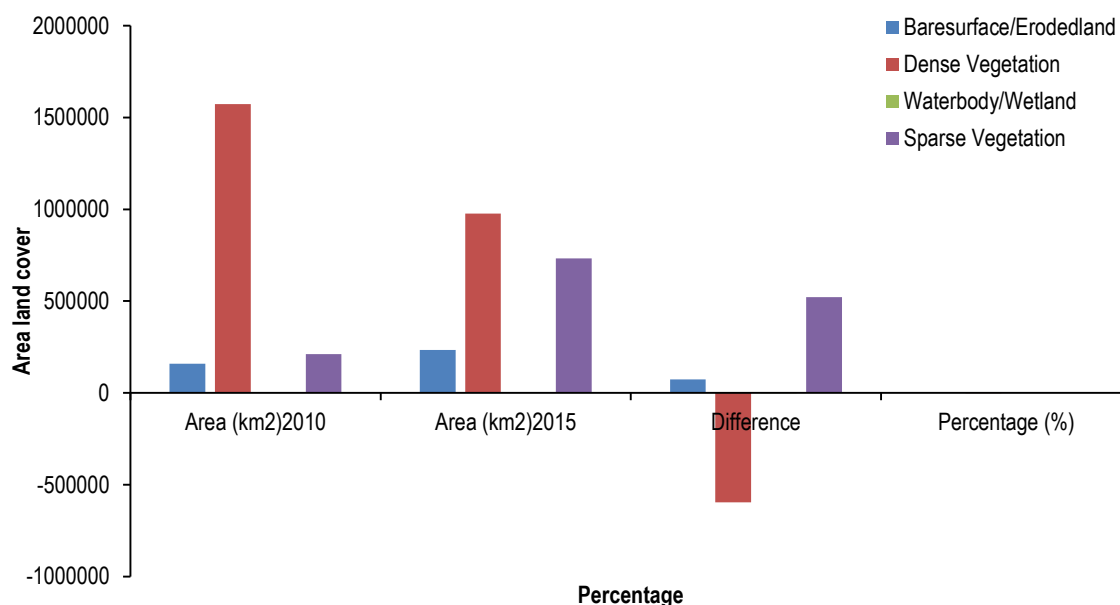


Figure 2: Land Cover Classes of Gashaka Gumti National Park (GGNP) Soil of the Study area "between" 2010 to 2015

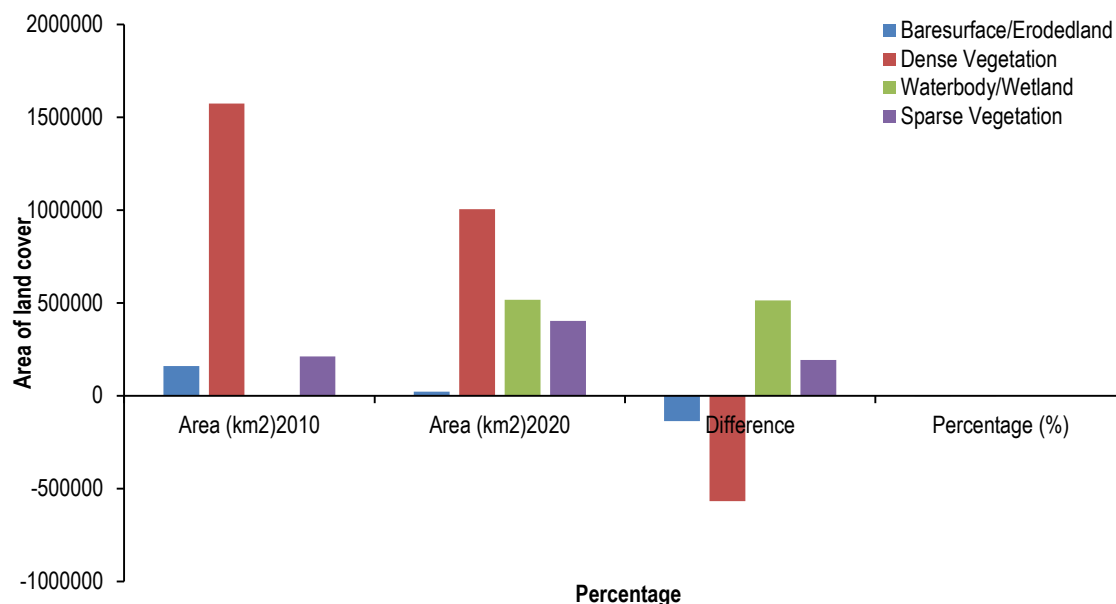


Figure 3: Land Cover Classes of Gashaka Gumti National Park Area from 2010 to 2020

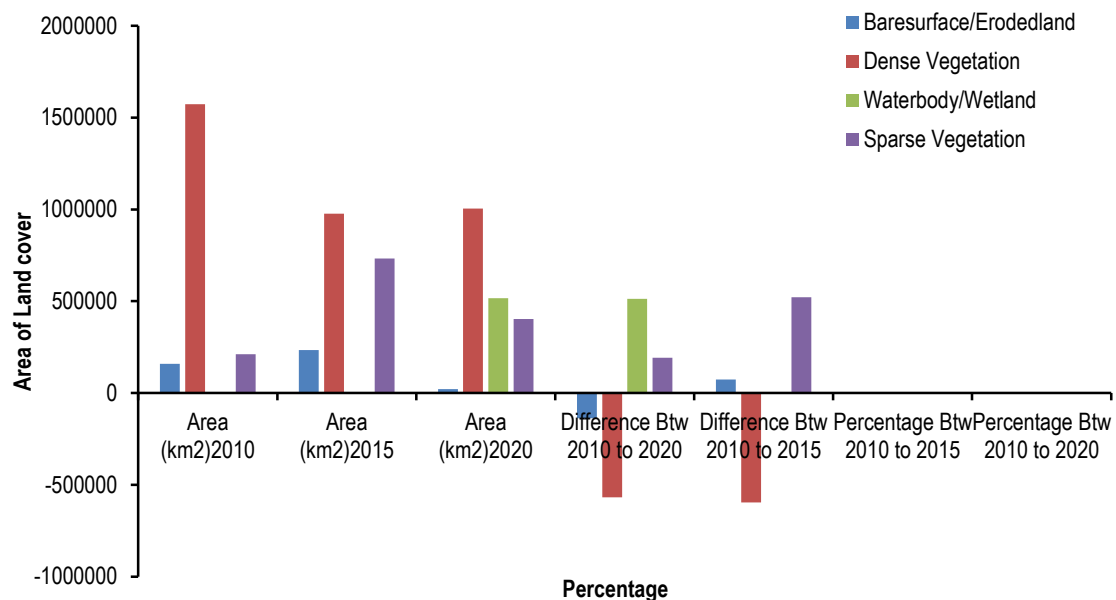


Figure 4: Land Cover Classes of Gashaka Gumti National Park Soil of the Study area "Between" 2010, 2015 and 2020

The decrease in the dense vegetation and Water body/Wetland is not unexpected. This may not be unconnected with the high incidence of anthropogenic activities such as deforestation resulting from expansion of human populations and cutting of trees for livestock feed as well as fuel wood harvesting. An earlier study by Bush [7], Pontius, *et al.* [16], Matthews, *et al.* [19], Jumpei, *et al.* [20] and Mottet, *et al.* [21] aimed at determining the effect of anthropogenic factors on biological resources is in conformity with this study. The concentration of the anthropogenic activities on the savanna habitats revealed that the dense vegetation provides the desirable woody plant species for livestock feed hence their cutting for animal feed and their use for fuel wood. The soil, terrain and the vegetation are also easy to manipulate for farming operations. These observations agree with that of Dishon

[13], Walz, *et al.* [17] and Jumpei, *et al.* [20] who reported on the threat factors affecting the rangeland of Adamawa State.

4. Conclusion

Four land cover classes were identified and studied in uncultivated soils of the study area. They include bare surface/Erode land, Dense Vegetation, water body/Wetland and Sparse Vegetation. Land cover classes change indicates that in 2010 Bare surface/Eroded land covered an area of 159195.416km² (8.18%), but increased to 233076.16km² (11.97%) in 2015 and land cover further decreased to 21456.63km²(1.10%) in 2020. Dense Vegetation was 1572846.60km² (80.81%), in 2010 and decreased to 977160.79km²(50.20%) in 2015 but increased to 1005393.45km²(51.65%) in 2020. Water body/Wetland was 3518.13km² (0.18%) decreased to 3125.00km² (0.16%) in 2015. And further increased to 515952.51 km² (26.51%)

in 2020. Sparse Vegetation had 210845.65km² (10.83%) In 2010, increased to 733043.84km² (37.66%) in 2015 further decreased to 403603.20 km² (20.74%) in 2020.

Thus Bare surface/eroded land cover increased by 3.80 % from 2010 to 2015. Dense vegetation and water body/wetland decreased by 0.02 % while sparse vegetation increased by 26.83 % between 2010 and 2015 respectively. However cumulative land cover change difference between 2010 and 2020 of the uncultivated bare surface/eroded land and dense vegetation decreased by 7.08 and 29.15 % respectively. Water body and sparse vegetation increase by 26.32 and 47.75 % within the same period.

Administered image classification technique studies of 2010 to 2015 and 2010 to 2020 imageries indicated changes in land cover classes. The Bare surface/Eroded land and Dense Vegetation land cover of the uncultivated land decreased in size by 7 and 29 percent respectively while Water body/Wetland and Sparse Vegetation cover increased in size by 26 and 47 percent respectively. In the cultivated area, farmland increased in size by 18.39 percent while Bare surface/Eroded land and Water body/Wetland decreased in size by 14 and 4 percent respectively. The investigation revealed that the major causes of the decrease of dense vegetation and sparse vegetation were anthropogenic activities. Such anthropogenic activities include expansion of farm land areas, expansion of settlements, bush burning, fuel-wood collection, local mining and cutting of timbers and browse plants.

Recommendations

- a. The study indicates drastic reduction in land cover, thus stringent measures should be employed by the appropriate authorities to prevent the conversion of forestland to cultivated land.
- b. It is therefore recommended that communities be sensitized on climate change and climate smart agriculture particularly those living within the local government area.
- c. People should be encouraged to practice Agro-forestry as well as Taungya system of farming and incentives be given to them where necessary.

Reference

- [1]. Achard, F., Eva, H.D., Stibig, H. J., Mayaux, P., Gallego, J., Richards, T. and Malingreau, J. P., (2002). Determination of deforestation rates of the world's humid tropical forests. *Science* 297, 999–1002.
- [2]. Rindfuss, R. R., Walsh, S. J., Turner II, B. L., Fox, J. and Mishra, V., (2004). Developing a science of land change: challenges and methodological issues. *Proceedings of the National Academy of Sciences*, 101, 13976–13981.
- [3]. Turner II, B. L., Lambin, E. F. and Reenberg, A., (2007). Land change science special feature: the emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences* 104, 20666–20671.
- [4]. Julia, S. R., Levers, C. and Henrie, E., (2018). Simulating and delineating future land change trajectories across Europe, *Regional Environmental Change*, 18, 733–749. Doi :10.1007/s10113-015-0876-0
- [5]. Nasselen. S. and Verburg, P. H., (2013). Land cover change or land-use intensification: simulating land system change with a global-scale land change model. Institute for Environmental Studies, VU University Amsterdam, De Boelelaan 1087, Amsterdam, HV 1081, Netherlands. doi: 10.1111/gcb.12331.
- [6]. Busch, G., (2006). Future European agricultural landscapes: What can we learn from existing quantitative land use scenario studies? *Agriculture, Ecosystems and Environment*, 114, 121–140.
- [7]. Bush, A., (2017) Connecting Earth observation to high-throughput biodiversity data, *Nature Ecology and Evolution*, 1, 0176. DOI: <https://doi.org/10.1038/s41559-017-0176>.
- [8]. Rudel, K. T., (2009). Paths of Destruction and Regeneration: Globalization and Forests in the Tropics, *Rural Sociology*, 67(4), 622–636.
- [9]. Samie, A., Deng, X., Jia, S. and Chen, D., (2017). Scenario-Based Simulation on Dynamics of Land-Use-Land-Cover Change in Punjab Province, Pakistan, *Sustainability*, 9(8), 1285. DOI: <https://doi.org/10.3390/su9081285>.
- [10]. Pickard, B., Gray, J., and Meentemeyer, R., (2017). Comparing Quantity, Allocation and Configuration Accuracy of Multiple Land Change Models. *Land*, 6(3), 52-61. <https://doi.org/10.3390/LAND6030052>.
- [11]. Vannier, C., Bierry, A., Longaretti, P., Nettiér, B., Cordonnier, T., Chauvin, C., Bertrand, N., Quétier, F., Lasseur, R., Lavorel, S. (2019). Co-constructing future land-use scenarios for the Grenoble region, France, *Landscape and Urban Planning*, 190, 103614, DOI: <https://doi.org/10.1016/j.landurbplan.2019.103614>.
- [12]. Heiserman, M., Mu"ller, C. and Ronneberger, K., (2006). Land in sight? Achievements, deficits and potentials of continental to global scale land-use modeling. *Agriculture, Ecosystems and Environment* 114, 141–158.
- [13]. Dishon, E. E., (2019). Deforestation and land use change: sparse data environments. *Agricultural Economics*, 27, 201–216.
- [14]. Guo, M., (2021). Soil Health Assessment and Management: Recent Development in Science and Practices. *Soil Systems*, 5, 61-75. <https://doi.org/10.3390/soilsystems5040061>
- [15]. Verburg, P. H., Rounsevell, M. D. A. and Veldkamp, A., (2006). Editorial. Scenario based studies of future land use in Europe, *Agriculture Ecosystems and Environment*, 114(1), 1–6.
- [16]. Pontius, R. H., Boersma, W., Castella, J. C., Clarke, K., de Nijs, T., Dietzel, C., Duan, Z., Fotsing, E., Goldstein, N., Kok, K., Koomen, E., Lippitt, C., McConnell, W., Mohd Sood, A., Pijanowski, B.,

- Pithadia, S., Sweeney, S., Trung, T., Veldkamp, A. and Verburg, P. H., (2008). Comparing the input, output, and validation maps for several models of land change. *The Annals of Regional Science*, 42, 11–37.
- [17]. Walz, A., Lardelli, C., Behrendt, H., Gret-Regamey, A., Lundstrom, C., Kytzia, S. and Bebi, P., (2007). Participatory scenario analysis for integrated regional modelling, *Landscape and Urban Planning*, 81, 114–131.
- [18]. Dunn, A., (2017). A training manual of survey and sampling techniques for census of large mammals in tropical forests. Report prepared for Worldwide Fund for Nature (WWF-UK), Wales, 1-20.
- [19]. Matthews, R., Gilbert, N., Roach, A., Polhill, J. and Gotts, N., (2007). Agent-based land-use models: a review of applications. *Landscape Ecology*, 22, 1447–1459.
- [20]. Jumpei, F., Jarvis, N., Koestel, J., Kätterer, T. and Larsbo, M., (2022). Global consequences of land use. *Science*, 309, 570–574.
- [21]. Mottet, A., Ladet, S., Coque, N. and Gibon, A., (2006). Agricultural land-use change and its drivers in mountain landscapes: a case study in the Pyrenees. *Agriculture, Ecosystems and Environment*, 114, 296–310.