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LAND USE AND LAND COVER CHANGE AND FOREST FRAGMENTATION IN PHIBSOO WILDLIFE SANCTUARY, BHUTAN

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Abstract
Land use and land cover (LULC) changes are driven by anthropogenic forces and it is essential to monitor the dynamics of LULC changes to conserve forest ecosystem. This research evaluated the LULC of Phibsoo Wildlife Sanctuary, one of the protected areas in Bhutan. The study was analysed using Landsat imageries for five years from 2017 to 2021 using maximum likelihood classification. This research also analyzed forest fragmentation using Fragstats, one of the landscape metric tools. Key findings revealed dense forest is being lost at worrying rate but agricultural land is increasing, triggered by the pandemic to ensure food security in rural Bhutan. It was also found that the proportion of degraded forest and barren land increased by 1.73 to 2.16 percent respectively.

In the landscape metrics it has depicted that the total area under forest, dense forest and moderately dense forest have been decreased whereas, the area under open forest and shrubs have been increased signifying that there is a loss of habitat for the wildlife. This research recommends Ministry of Agriculture and Forestry and Department of Parks and Services to find out the alternative interventions to control the forest fragmentation and change of LULC in wildlife sanctuary.

Keywords: *Landscape Metric, Fragstats, Land Use and Land Cover, Phibsoo Wildlife Sanctuary*

INTRODUCTION

The environment changes and deterioration are the global concern often being caused by the human acts and ecological processes. The human approaches towards natural landscape with the advancement of technology and social political organization leads to the change of natural landscape to the cultural landscape leaving the human impression everywhere. Moreover, the constant increase in human population exerts the relentless pressure on natural environment and this demand driven development activities have amplified enormous pressure on earth's environment (Vesburg et al., (2006; Majumder, 2010) The needs of burgeoning population changes with changing time with advancing technologies and have heavily depleted the natural resources leading to change in LULC. But the brunt of LULC on the natural environment are not carefully examined which indeed, have the multiple facets, including climate change, impairment of water quality, alteration of hydrological cycle, and loss of biodiversity (Turner et al., 2007).

The LULC change is one of the imperative topics in research due to complex interaction between human and physical environment. LULC are intrinsically coupled because of changes in LULC, and land cover enables the land use. (Greechi et al., 2018) and these changes are induced by both human and climate.The LULC change can reflect the patterns of human land use change in a region, helping us to cope with global climate change and sustainable development (Chang et al., 2017). Since 18th century, the changeover earth surface occurred drastically with advancement of ideas and technology and the implementation of those sophisticated technology has given the rise in LULC change leaving the human impression everywhere. The natural land was transformed ever more into cultural landscape impacting the vegetation and global climate at large.

To maintain the land cover, land use is must to view it judiciously as land use involves the management otherwise, this might lead to the human land use conflicts. Ever since mid of eighteenth century, the deforestation has been the primary causes of massive land cover change in the world. However, in recent times, the use of land for urbanization is one of the major landcover changes. Food and Agriculture Organization of the United Nations [FAO] (2019) stated that the land degradation is being exacerbated due to absence of proper land use planning.

LULC change studies are often used to understand the spatial and temporal changes in land use and to enable more comprehensive planning. Forest cover change is a global problem because forests have the ability to store carbon and are critical to maintaining global and regional biodiversity. However, through natural and anthropogenic processes, mountain ecosystems and forests are experiencing significant changes in land use (Saikia et al., 2016; Sharma, Robeson, & Thapa, 2016).

In fact, landscape patterns that accrue from the LULC hinder the complex relationship between abiotic and biotic and human use of land are the key driver (Saikia, Hazarika, & Sahariah, 2013). Therefore, understanding the relationship between the LULC and landscape pattern is paramount to enhance the land management and environmental sustainability. This will help in mitigating the negative effects on land use reducing the impact on future generations.

The land use application involves use of baseline mapping and subsequent monitoring, since it examines the spatial change in temporal aspects enabling us to know the changes occurred in different timing. Today, the LULC changes are at greater pace than ever before in human history due to increase of human encroachment in increasing rate. Technological advancement and increase in human greed are other reasons for LULC changein which natural vegetation is destroyed indiscriminately. With the greater emphasis given on study of LULC, the researchers have recognized that the human activities have led to the global environmental change (Chang et al., 2017). LULC helps in developing strategies to conflicting use, balance conservation, developmental pressure, and disturbance of productive land, depletion of forests and urban encroachment (Bhatta, 2019). Therefore, the forest conversion and degradation are treated as the most imperative factor which contributes to the decline and loss of worldwide species diversity (Noss et al., 1994).

Apart from the impact on biodiversity, forest fragmentation is a critical aspect of distribution of ecological system since forest species are adapted to either edge or interior habitats. The indicator of forest fragmentation was initially developed by United States Department of Agriculture (USDA) forest service and has the potential to depict the considerable regional variation. Forest fragmentation can be defined as breaking of large and continuous forest areas into smaller patches separated by roads, utility corridor or other human developments. Fahrig (2003) defined that it is a process where large expanse of habitat is transformed into a number of smaller patches isolated from each other by a matrix of habitats, whereas forest fragmentation refers to the conversion of continuous forest into a patch of forest separated by non-forested land. In fact, forest fragmentation can also have negative impact on ecosystem processes and services (Baulies et al., 1997; Burkhard et al., 2009; Laurance, 2007). Therefore, forest restoration based on ecological criteria can improve the forest structure and landscape connectivity, promoting the connection between the protected areas and other forest fragments.

Study area

LULC change is one of the major issues in Bhutan since Bhutan has the highest per capita fuel wood consumption in the world (Tashi, 2019). In order to control land use and change, the government has enacted timely laws and policies and committed to continuously covering 60% of the total geographical area with forest in the Constitution of the Kingdom of Bhutan (2008). On the other hand, the demographic pressure with annual growth rate of 1.05% in 2018 (National Statistical Bureau, 2019) with highly uneven distribution of population exerts the tremendous pressure on the land use and land cover change. Equally, the government objective towards accomplishing self-reliance throughdiversification of agriculture such as cereals and essential oil crops are in the top priority since past decade causing change in LULC.

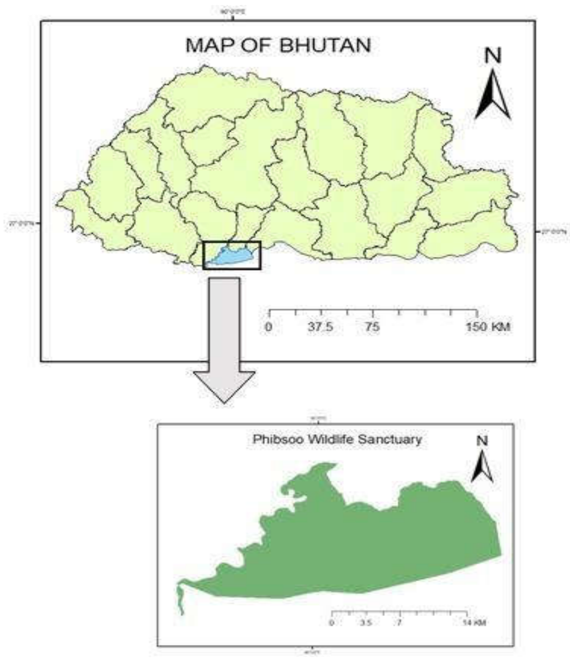


Fig. 1. Location of Phibsoo wildlife Sanctuary

The Renewable and Natural Resource Statistical Division Directorate Services [RNRSDDS] (2019) conducted the LULC change in nationwide in considering three important aspects of agriculture such as Chuzhing, Kamzhing and Orchard (wetland, dry land and orchard). It has found out that the land use changes are constantly changing, for instance, chuzhing in 2010 was 31146.10 with 69440.6 kamzhing and 11523.40 orchard in hectare, whereas in 2016, 5559.60, 47395.59 and 9091.82 hectare respectively (National Statistical Bureau, 2020). Therefore, the agriculture practices have changed tremendously over the years from subsistence to commercial farming. But very few studies have sought to understand the dynamics of LULC change over time and space. This is mainly because of limited spatial information regarding land use conditions.

Bhutan is a small landlocked kingdom sandwiched between the two giants of Asia, north by China and south by India. Bhutan embarked on middle path policies of economic development and conservation of natural environment (Fig.1.location of Phibsoo wildlife Sanctuary) placing both at par. Bhutan has developed the overarching developmental philosophy Gross National Happiness which guides the economic development and the preservation and conservation of Natural environment. So, in pursuit of Gross National Happiness (GNH), Bhutan endorsed a system of protected area for green and friendly environment, considering the multi-generation benefits. Moreover, the constitution of Bhutan mandates to maintain minimum of 60% of total geographical area under forest covers throughout and in lieu, Bhutan has total of ten major national parks and wildlife sanctuaries which comprise of more than fifty percent of total geographical area of Bhutan.

Of these ten national parks and protected areas, Phibsoo is the second smallest protected area, covering a total area of 287 km². Phibsoo is located in the sub-Himalayan foothills of south-central Bhutan, exactly at the latitude of 2642 to 2651 N and 8956 to 9012 E. The Phibsoo Wildlife Sanctuary is divided into two different areas due to the geographical setting in which it lies Area offices administer two southern districts; Sarpang and Dagana. To the south, the Phibsoo Wildlife Sanctuary is bounded by the Ripu Chirang Reserve Forest on the Indian side, to the west it is bounded by the Sunkosh River, to the east by the Singye River and to the north by the Dhaneshri Ridge (Norbu, 2012).

Phibsoo Wildlife Sanctuary has immense significance as it not only protects the southernmost variant subtropical Himalayan Forest ecosystem but also serve as critical sources of several seasonal and perennial streams which contribute significantly to the livelihood of Assam Daurs. The water that originates from this pristine sanctuary is the source of livelihood for many people residing in terrai region of Assam adjoining to southern border of Bhutan.

Bhutan, despites being a rich biodiversity with pristine environment covering more than 70 percent of total geographical area, LULC change and forest fragmentation studies using the recent technologies and techniques are rarely being done (Sharma et al., 2016). This research indefinitely adds the value to the protection and conservation of natural environment in this wildlife sanctuary.

Additionally, the human residents are another source of LULC change in this sanctuary. The Economic Survey (2009) shows that there are twenty-one villages and hamlets in and around Phibsoo Wildlife Sanctuary with a total population of 2611 people. Of these, 48 percent live within the protected area, with a population density of 4.7 people per km² (Norbu, 2012). This population constantly interacts with the forest ecosystem and their dependence on the forest, such as for timber and forest firewood, is increasing at an alarming rate, resulting in a change in LULC in Phibsoo Wildlife Sanctuary.

Agriculture is the primary source of the people dwelling in this area and rearing of cattle; free-range grazing in the forest habitats is serious concern for the depletion of the forested area which indiscriminately leads to change in land cover change. The cattle in large numbers are left out in the forest for free-range grazing causing the threat to the sanctuary like overgrazing, loss of vegetation and soil erosions (Bennett & Saunders, 2010; Norbu, 2012; Reddy, 2006).

The poaching of logs for the commercial as well as personal purpose are rampant in this area from neighbouring districts of Assam as well as Bhutanese dwelling near to the wildlife sanctuary. This has impacted largely in the development of habitats and wildlife ecosystem as poaching and hunting are often seen in this area due to high porosity of the border area as well as accessibility to the sanctuary from the neighbouring settlements (Aspinall,2004; Majumder, 2011; Norbu,2012).

Besides these, there is no detailed study conducted in this region which can help in planning and conservation interventions. The dearth of research and information are in daring need to implement and execute the policies and plans. The types of forest and land use and land cover change classification along with the fragmentations are yet to be carried out in this wildlife sanctuary.

Methodology

Landsat 8 OLI images were used to determine the LULC of this study area, taking into account the minimum cloud cover and time frame. To avoid the seasonal variations of LULC as shown in Table 1, the images of the same time in different years were considered. ArcGis 10.3 and Fragstat software were used to perform supervised classification using the maximum likelihood algorithm method (Benz et al., 2004; Codjoe et al., 2007; Enderle & Weih Jr, 2005). The LULC was classified into water bodies, settlements, agricultural lands, barren lands, degraded forests and dense forests using ArcGis 10.3. The descriptions of the LULC categories are defined in Table 2. Fragstat was used to analyze forest fragmentation by categorizing into dense forests, moderately dense forests, water bodies, open forests, barren lands and shrubs using the Forest Survey of India (FSI, 2013) classification schemes. Google Earth and GPS were used to derive the ground control points (GCPs) and also to carry out ground truthing. It was found that the overall Kappa accuracy is 93.28% for 2017 and 91.26% for 2021 and the Kappa coefficient is also 90.18%.

Table 1 *Satellite Data used in LULC Classification*

Satellite	Number of bands	Resolution (m)	Path/ Raw	Observation date	Source
Land sat OLI 8	9	30	138/041	27 March, 2017	USGS Glovis
Land sat OLI 8	9	30	138/041	24 March, 2021	USGS glovis

Table 2 *Description of LULC Categories*

LULC category	Description
Agriculture land	The land that is under the cultivation which can be winter or summer crops including animal feeds and also depicts the imprints of agriculture practices during the time of study
Barren land	The bare land with no crops for long duration or otherwise a land that has no imprint of agriculture during the time of study
Dense forest	The areas which have the canopy density above 40% which can be further classify into very dense and moderately dense forest on the basis of canopy density
Open Forest	The areas with the canopy density ranging from 10% to 40%
Shrubs	The canopy density less than 10%

By using the Fragstats, the following are being analyzed i) number of patches (NP), ii) Patch type or the percentage of landscape in particular class (PLAND), iii) Landscape mean and iv) Edge Density (ED). The change of land use and land cover (LULC) was calculated by using arcgis and the forest fragmentation was analyzed by using the Fragstats (McGarigal, et al. 2012) which has the power to quantify the composition and configuration spatially.

Patch standard deviations formula from the class mean were calculated by using the formula; CSD= $\frac{X_{ij}-\bar{x}_i}{S_i}$

Where, Xij= Metric value of a patch ij, $\bar{X}_i$=Mean value of the corresponding patch metric (Patch type class i), S_i=SD of the corresponding patch metric (Patch type class i). For the Class Distribution Percentile, the formula used is; CPS= $[\frac{RANK\ (X_{ij})-1}{n_1-1}](100)$

Where, Xij= value of patch metric ij, n_1= Number of patches in type class I and for the standard Deviation from the Landscape Mean LSD= $\frac{X_{ij}-\bar{x}}{S}$

Where, Xij= Metric value of a patch ij, $\bar{X}$= Mean value of patch metric in all patches in the landscape and S= SD of all the patches in the landscape.

Results and Discussion

To conserve current natural resources and also understand the causes and consequences of over-exploitation, LULC mapping and monitoring is required (de Jong et al., 2001; Hassan et al., 2016) and therefore land use and land cover change Phibsoo Wildlife Sanctuary was analyzed over the five-year period from 2017 to 2021. Land use and land cover changes during half the decade were enormous in this small protected area, as shown in Table 3 and Figure 1. The government of Bhutan aims to create rich forests and biodiversity with strict policies to continue to preserve the pristine environment, but changes in land use and land cover remain out of control.

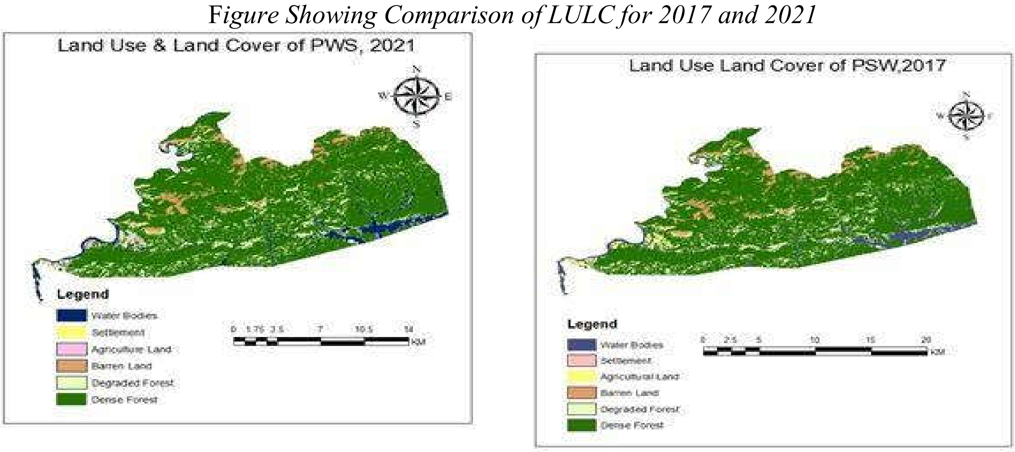
Table 3 *Land Use Land Cover change from 2017 to 2021*

	Area in Sq. km			
LULC Class/Year	2017	2021	2017(%)	2021(%)
Water Bodies	15.73	15.68	5.480836	5.463415
Settlement	0.52	2.1	0.181185	0.731707
Agricultural Land	2.02	5	0.703833	1.74216
Barren Land	14.61	20.82	5.090592	7.254355
Degraded Forest	32.03	37.01	11.16028	12.89547
Dense Forest	222.35	206.39	77.47387	71.91289
Total Area in Sq.km	287	287	100	100

Deforestation represents the single greatest threat to biodiversity, leading to habitat loss and fragmentation (Sala et al., 2000). As shown in Table 3 and Figure 1, anthropogenic impacts are high where the loss of dense forest habitats is decreasing at an alarming rate. In five years, Phibsoo Wildlife Sanctuary lost 15.96 square kilometers of dense forest, accounting for 5.56 percent of PWS's total protected area. This results in an annual average loss of dense forest in this protected area of 1.11 percent; However, the total forest cover still remains high. In 2021, the forested area, which includes degraded forests and dense forests, is 243.4 square kilometers, accounting for 84.80 percent, but it was found that there was a significant loss of forest habitats. It has decreased by 88.63 percent from 254.38 square kilometers to 84.80 percent within five years. If the same loss trend of 10.98 square kilometers continues over five years, there would be a loss of 109.8 square kilometers over the next ten years, which is almost a third of the protected area. Taking these statistics into account, it is clear that the average annual forest loss is 0.76 percent, which is well over double the country's average annual forest loss of 0.35 percent (FAO, 2020).

Figure 2

Figure Showing Comparison of LULC for 2017 and 2021



Bhutan having the least physiological density in Asia, the agricultural land in Bhutan is constantly growing at the rate of 0.72 percent annually since 1969 (Chhogyel et al., 2020; Yangchen et al.,2015). Alike, the agricultural land in my study also shows similar result. For example, the data on Table 3 and Figure 1 reveals that the area under agriculture shot up drastically within half the decade from 2017 to 2021. The agricultural land in 2017 was just 2.02 sq km which comprise 0.70 percent while in 2021 the agriculture land has increased to 5 sq. km making up to 1.74 percent which isan increase of more than the double at the average annual growth rate of 0.208 percent.

The above change may be attributed to maintain the food security during the pandemic time as Bhutan is a land locked country. The Royal Government of Bhutan and the International Organization like FAO provided the huge incentives to strengthen the food security of rural people as more than 60 percent of population are residing in rural Bhutan. Moreover, the price for the agriculture products has shoot-up drastically which gave the encouragement to the rural farmers to actively involve in agriculture practice. Moreover, it is mainly because of increase in number of settlements which is discussed in next section.

As Bhutan has stringent policies in place to control and maintain the protected areas, the settlements in protected areas are prohibited unless they have settled right from the ancestral time. Despite the stringent polices in place, my finding shows the settlement has continued increasing for last five years from 0.52 sq km to 2.1 sq. km as evident from Table 3 and Figure 2. The reason for increase settlement is due to increase in population residing in this area.

Pertaining to the barren land, similar to the settlement and agricultural land, it continued to increase, however, the reason for increase in barren land is not known yet, can premise due to change in river course as most of the barren land are detected nearby river courses. The barren land has increased from 5.09 percent to 7.25 percent at the average annual growth rate of 0.43 percent. Despite the little changes of river course, the land under water remains almost constant for last five years.

The landscape Metrics and fragmentation

The patch density measures the number of patches and depicts the changes occurred in different small patches which are one of the important factors indicating the landscape fragmentation. In fact, the landscape is an area of land which contains the mosaic of habitat patches in a particular focal or target habitat patch is entrenched (Dunning et al., 1992; Kaul & Sopan., 2012). The forest edge effect helps in understanding the relation between the spatial heterogeneity in particular landscape and the myriad ecology (Li et al., 2017). Therefore, percentage of landscape (PLAND) is a fundamental measure to understand the landscape composition in context of types of patches in particular area. An increase in patch index shows there is increase in species richness which helps in conservation of forest flora and fauna as well as maintaining the healthy ecosystem functioning. But by-product of the habitat fragmentation is indeed, the habitat loss. Despite PLAND, there are numerous indices to study the forest fragmentation such as number of patches, mean patch size and edge density.

The study shows that the PLAND percentage of dense forest consistently declined since 2017 to 2021 from 14.12percent to 13.5 percent as shown in Table 4. Similarly, the PLAND of water bodies also declined slightly from 2017 to 2021 but opposite to it, shrubs started increasing from 2017 till 2021 as evident in Table 4. The PLAND for the Open Forest has increased almost to the triple fold from 3.78 to 10.64. These signify that there is high rate of forest fragmentation in this sanctuary where as the PLAND for water remain almost constant as shown in Table 4.

Table 4 *Percentage of Landscape (PLAND) for LULC categories*

Land use/ land cover categories	PLAND (%)	
	2017	2021
Dense Forest	14.12	13.5
Moderately dense forest	4.52	5.75
Water	1.76	1.65
Open forest	3.78	10.64
Barren Land	0.003	0.42
Shrubs	3.44	4.31

The higher number of patches actually indicates there is richness of species for their varied habitats, of course all ecology do not fit in one suit (Lambin., Geist., & Lepers,. 2003). Yet, by taking to the consideration of health of the forest, increasing the number of patches signifies there is constant pressure to the forest leading to the forest fragmentation. The Table 5 shows there is continuous increase in number of patches in all the classes which is a sign of higher rate of forest fragmentation. Within half the decade the number of patches of dense forest has increased from 16223 to 18224 which is an increase of 12.46% and the number of patches in moderately dense forest increased continuously within the study period having an average increase of 315 numbers of patches annually. This was the same case with shrubs as shown in Table 5. Moreover, there is increase in number of patches in water bodies as well as barrenland indicating that the rate of fragmentation is high in these areas. There is remarkable change in number of patches in barren land increasing from 11,364 to 16,998 where the annual increase of 1127 patches.

Table 5 *Number of patches (NP) for different LULC categories*

Land use/ land cover categories	NP (Number of Patches)	
	2017	2021
Dense Forest	16223	18244
Moderately dense forest	15,783	16,981
Water	8451	12,004
Open forest	8973	12,452
Barren Land	11,364	16,998
Shrubs	6097	8015

Mean patch size is the number of patches in the class and the total area. It is derived from the number of patches showing average condition of the patch size. It even describes the area of a patch or fragment occurred within the landscape. The mean patch size continuously declined for the last five years in four categories such as dense forest, moderately dense forest, open forest and water bodies but to the opposite the mean patch size of barren land increased more than a double fold from 0.74 ha to 1.87 ha indicating that there is a deterioration of the forest by increasing the sizeof the patches in fallow land since there are number of causes such as human encroachment into the restricted area, illegal logging by bordering areas due to high porosity in the boundary, free grazing of cattle and poaching (Norbu, 2012). Even in shrubs the mean patch size has been increased from 0.23 to 0.31 ha as shown in Table 6.

Table 6 *Mean Patch Size (Ha) for different LULC*

Land use/ land cover categories	MPS (Mean Patch size) in ha	
	2017	2021
Dense Forest	9.01	4.47
Moderately dense forest	1.01	0.43
Water	1.21	0.23
Open Forest	1.04	0.87
Barren land	0.74	1.67
Shrubs	0.23	0.31

Edge density is one of the important components to portray the forest fragmentation. Increases in edge density are primary outcome of forest fragmentation which directly means that there will be habitat fragmentation. Generally, the landscape with large patches or simple shapes will have lesser edge density than the landscape with irregular or the small patches (Sharma et al., 2016). Forsooth, edge density describes the distance of an ecosystem from the center of thepatch. Since habitat fragmentation is the major global problem which is indeed imperative to preserve flora and fauna, Bhutan has adopted the policies of middle path. However, the habitat fragmentation is one of the serious concerns in Bhutan. There is constant anthropogenic pressure to the protected area and the study shows that the edge density for the dense forest continued to increase for last five years from 28.87 to 30.67 ha-1 indicating there is huge loss of habitat for the wild animals. Similarly, the moderately dense forest and open forest have also increased gradually from 32.56 to 38.76 ha-1 and 27.87 to 29.56 ha-1 respectively as evident in **Table 7**. The increase in edge density symbolizing the forest fragmentation and would disconnect ones habitats from others causing the human-wildlife conflicts. Shrubs also without exception increased its edge density from 25.43 to 31.86 ha-1 on an average annual growth rate of 1.286 ha-1.

Table 7 *Edge Density (ED) in (Ha)*

Land use/ land cover categories	ED (Edge Density) in ha-1	
	2017	2021
Dense Forest	28.87	30.67
Moderately dense forest	32.56	38.76
Water	3.68	4.07
Open forest	27.87	29.56
Barren Land	1.04	0.87
Shrubs	25.43	31.86

Conclusion

This research explored the land use and land cover change in Phibsoo wildlife sanctuary, the second smallest protected area of Bhutan which comprised of 287 sq km located in southern belt of Bhutan. This research has analyzed the data for last two years 2017 and 2021 for the interval of five years using the satellite data.

This research has two distinct methods employed. The first has used supervised classification by using maximum likelihood classification integrating Remote Sensing Satellite data with Geographical Information System (GIS) 10.8 to find it out the land use and land cover change whereas, the second part has focused on forest fragmentation using the Fragstats as a tool to analyze it.

This study has classified the land use categories into six such as dense forest, degraded forest, water, barren land, agricultural land and settlement but in forest fragmentation it has classified into dense forest, moderately dense forest, open forest, shrubs and water and barren land to depict the status of forest fragmentation.

The results showed that the area has undergone continues change in LULC with varying magnitude and rates. The key finding includes the area under dense forest has changed tremendously from 77.47 percent to 71.91 percent within half the decade at the average annual rate of 1.112 percent. The losses of dense forest are inclined to poaching from the neighbouring settlers as well as free range cattle grazing in this protected area.

Similarly, it has also found out that the settlement area under this protected area has been increased despite the stringent laws implemented by the government. The area under settlement has increased from 0.18 percent to 0.73 percent within the span of five years. In lieu, the agricultural land has drastically increased during the pandemic times due to incentives schemes introduced by the government and other international organizations to reduce the risk of rural food security. Moreover, the price hike for the agriculture products during pandemic times has encouraged the farmers to take part actively in agriculture.

The area under degraded forest has increased gradually from 2017 to 2020, however, it was found out that the area under degraded forest has been reduced in following year from 41.7 sq km to 37.01 sq km; of course, the area under degraded forest has increased at the average annual growth rate of 0.348 percent.

Conservation and preservation of habitats for wildlife are increasingly important, therefore, it is must to continue spatial and temporal composition of forest ecosystem which can enhance the wealth of biodiversity. The Fragstats, the tool to study the landscape forest fragmentation has revealed that there is constant pressure exerted on the habitats of the wildlife. There is huge loss of dense forest and also shows the breakage of linkages between the habitats of wildlife which will lead to the loss of biodiversity in long run.

This research recommends the Ministry of Agriculture and Forestry to have a planned policies where the bio-habitats in reserved areas are not being hampered by anthropogenic forces. The Department of Parks and Services must implement the appropriate measures to reduce the forest fragmentations. The community must adhere with the policies in place and uphold the sanctity of protected areas.

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