Assessing natural resource change in Vhembe biosphere and surroundings

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Abstract

South Africa is a custodian of an immense wealth of natural and biodiversity resources in Africa. Natural resources are continually changing in different South African biospheres based on anthropogenic and non-anthropogenic causes. Land use activities like agriculture, cultivation, livestock rearing, commercial plantations, urbanisation and mining are among the major drivers of natural resource change and transformation. In this study, land cover change assessment was used to assess natural resource change in Vhembe biosphere and surroundings. To assess natural resource change in Vhembe biosphere, land use land cover change assessment was conducted using South African's national land-cover dataset, generated from multi-seasonal Landsat 5 and Sentinel-2 images. The 72× class land cover map was re-classified into 12× classes to fit the study objectives. Eight out of twelve classes quantified in hectares: indigenous forests, thicket/dense bush, natural woodland, shrubland, grassland, water bodies and wetlands were categorised as natural resources for which the natural resource change assessment for this study was based. Assessment findings established that land use and its related activities have contributed substantially to natural resource change where cultivated commercial, natural woodland and built-up residential contributed the most significant upward change in hectarage and percentage, from 132,246.9 to 365,644.92 (ha)—percentage change of 176%; from 94,665.42 to 257,889.68 (ha)—percentage changes of 172% and from 74,070.27 to 147,701.88(ha)—percentage change of 99% respectively. Shrubland, thicket/dense bush and indigenous forests registered the highest downward changes from 263,070.6 to 977.72 (ha); from 338,723.7 to 23,166.92 and from 13,211.91 to 7402.92 (ha) with percentage changes of −100%, −93% and −44% respectively in Vhembe biosphere and the surroundings from 1990 to 2018. The study showed how natural resources are changing and the use of remote sensing for environmental monitoring and assessment in the Vhembe district.

Keywords

- Natural resource change
- Biosphere region
- Land cover classes
- Land cover change

Introduction

Mounting pressure on natural resources continues to drive high demand for both basic and key natural resources in developing and developed world. In addition, water scarcity, energy shortages and other pre-existing conditions including poverty and social inequality pose major threats to the already diminishing natural resource bases. Maintaining constant and exponential demand for livelihood survival and keep up the sustainability base of natural resources is one of the twenty-first century developmental challenges facing the world (Azevedo et al., 2014; Rosegrant et al., 2001). Discussions of natural resource depletion currently presume that the world is entering a critical regime of natural resource stresses due to several factors (Mittal & Kumar, 2015; Bengtsson et al., 2018). Urbanisation and increasing population growth are expected to double global natural resource demand for the foreseeable future (Madlener & Yasin, 2011; Rosegrant et al., 2001; Tesfa et al., 2015). These trends in demand have important implications for natural resources that provide essential support to life and economic processes in the future.

The extent and level of natural resource exploitation, use and management, particularly, vegetation, land, forests and water in the world, have consequently contributed significantly to natural resource and environmental degradation (Mucova et al., 2018; Cimon-Morin et al., 2016) leading to serious consequences in the reduction of ecosystem services and food production (Cimon-Morin et al., 2016; Basane & Gambiza, 2016; UNECA, 2011; IPBES, 2018). Changes with a decline in ecosystems and natural resource base have been associated with extensive land uses emerging from anthropogenic factors (Rawat et al., 2013; Butchart et al., 2010; Chapin et al., 2000; IPBES, 2018) such as agricultural intensification, livestock grazing urbanisation, infrastructure development and deforestation (Halmy et al., 2015; Rawat et al., 2013; Berberoglu & Akin 2009; Thomas et al., 2000) and exacerbated by climate change (Warren et al., 2013; IPBES, 2018; WWF, 2020; CBD, 2020) particularly because climate change accelerates habitat destruction, overexploitation and prevalence of invasive species (Brook et al., 2008). Land use and related activities have significant impacts on natural resource changes (Basane & Gambiza, 2016; Dale et al., 1998). Human activities ranging from agricultural practices (Rouget et al., 2003; Millennium Ecosystem Assessment MA, 2005), urbanisation and industrialization (McKinney, 2008; Marzluff et al., 2001) with related activities are among the common human and societal land use activities that can significantly alter the natural resource base of an area leading to the removal and alteration of indigenous vegetation (Sultan, 2016; Uttara et al., 2012; Chapin 111 et al., 2000; Diaz et al., 2006; Dale et al., 1998). These changes have intense implications at regional and global scales for global natural resource losses (Lambin & Geist, 2006). Globally, there is a consensus that climate change, overexploitation, land use change, alien species and pollution contribute immensely to the biodiversity loss (CBD, 2020; WWF, 2020; IPBES, 2018). On a local level, activities leading to changes in the use of land affect watershed runoff, microclimatic resources, processes of landscape-level biodiversity, soil erosion and land degradation (Sultan, 2016). Such land use activities have significant potential to expose the impact of land change on natural resource change in a given biosphere.

South Africa is the most biological habitat for an extensive base of biodiversity resources (Basane & Gambiza 2016; Shackleton et al., 2009) and estimated to be the third most biodiverse country in the world (Brownlie et al., 2017; Cadman et al., 2010; Wynberg, 2002). At the ecosystem level, these biodiversity resources underpin the production of goods and services (Norris, 2012) used by vast populations, for example, natural forests, water, shrub-land, cultivatable land and natural woodland (Scholes et al., 2008; Biggs, 2004). Local-based, natural resource–based harvesting distributes wide ranges of consumable products to a majority of poor and rural-based South Africans (Shackleton, 2009) as well as income for equally significant numbers (Lawes et al., 2004; Twine et al., 2003).

The well-being of most South African rural-based communities lies with natural resource harvesting and usage (Shackleton et al., 2008; Shackleton et al., 2007). Despite substantial electricity provision, most rural and significant proportions of rural South Africans continue to rely on natural forest and woodland as a source of energy for cooking and construction materials (Madubansi et al., 2006; von Maltitz & Shackleton 2004), a significant factor that contributes to natural resource consumption and change.

Land cover has been done extensively using remote sensing (Butt et al., 2015). Several techniques such as supervised (Lillesand et al., 2008; Jensen, 1996) and unsupervised (Lillesand et al., 2008; Jensen, 1996) classification have been used, including parametric (Laurence, 2001) and non-parametric classifiers in land use and land cover change analysis (Laurence, 2001). In this study, existing land cover maps obtained from South African National Land Cover (SANLC) will be used for land use land cover change (LULCC) analysis. This paper focused on natural resource change analysis in Vhembe biosphere for the last 20 years to provide relevant and scientific information for decision-making on natural resource change causes and inform appropriate decision-making strategies. The intention of this study is not to assess the classification capabilities of the use of remote sensing data to undertake land cover classifications but to use the existing and highly accurate land cover product to assess natural resource change.

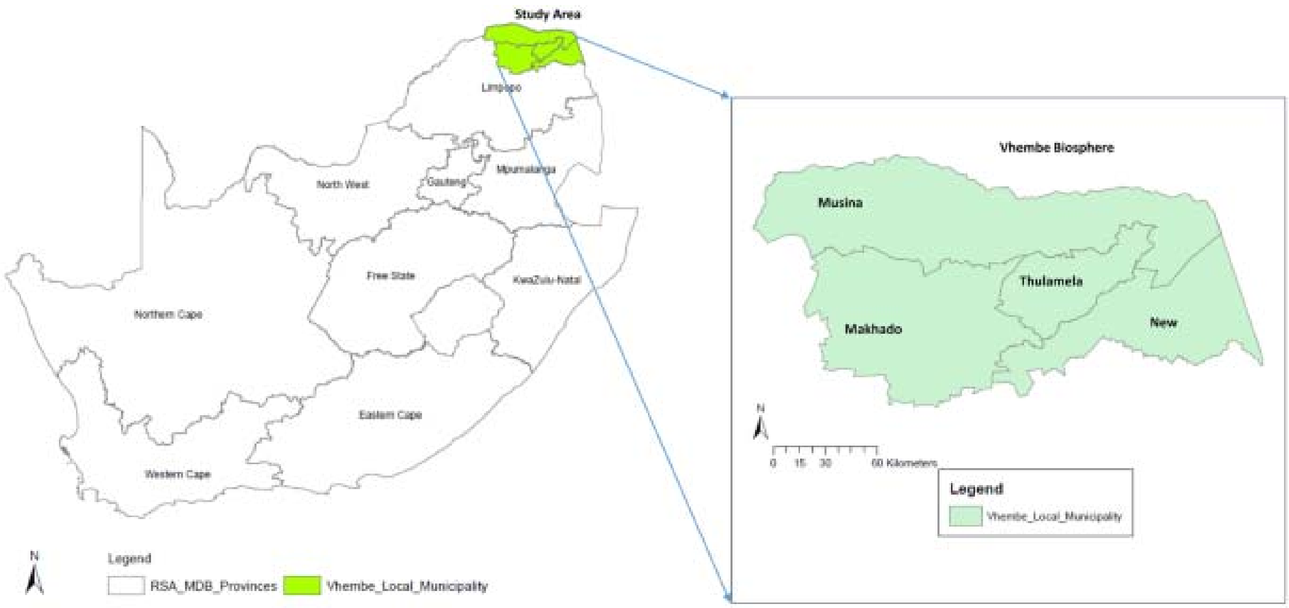
Considering the high demand for such natural resources, it is not surprising that there has been a significant dwindling of natural resources, at local, national and international level. The total quantification of natural resource change is not fully documented and recorded for most rural areas across the world, and Vhembe biosphere and its surroundings is not an exception. Vhembe biosphere is of a remarkable diversity of ecosystems and natural resources (Setshego et al., 2020; Dombo et al., 2006; Hahn, 2006) and series of land use activities. Land use and consequential land cover change as indicators of natural resource change would be a valuable source of knowledge to inform policy on how to manage and inform decision-making. Land use land cover analysis would assist in understanding why, how, where and the extent to which natural resource change is occurring and associated effects. This could be true in the Vhembe biosphere region, where natural resource loss (i.e. vegetation) is not only driven by climatic conditions but also dependent on anthropogenic factors and processes (Wilson & Juntti, 2005). Therefore, remote sensing–derived land cover products will be used effectively in assessing the natural resource change in Vhembe biosphere, and the main questions are:

- What is the quantification of natural resource distribution in the study area from 1990 to 2018?
- What has been the natural resource change between 1990 and 2018?
- What is the rate of change for natural resources between 1990 and 2018?

Study area

A biosphere region comprises different zones that represent different kinds of land use (Basane & Gambiza, 2016) and connects potential compatibility between nature and people (Price & Persic, 2013), bridging conservation and development agenda (Foggin, 2016; Price

& Persic, 2013). Vhembe biosphere (Fig. 1) is located in the north-east of South Africa near the border with Botswana, Mozambique and Zimbabwe (Dombo et al., 2006; https://www.vhembebioshere.org/) and lies between 22° 07′ 32″ S and 23° 34′ 14″ S latitude and 28° 39′ 32″ E and 31° 33′ 49″ E longitude, midpoint at 22° 051′ 17″ S 30° 06′ 13″ E) (Hahn, 2017; https://www.vhembebiosphere.org/). The biosphere includes the northern part of Kruger National Park, Mapungubwe World Heritage site, a number of provincial nature reserves, two recognized centres of biodiversity and endemism—Soutpansberg and Blouberg (Van Wyk & Smith, 2001) and the Makgabeng Plateau (Hahn, 2017; Dombo et al., 2006; Van Wyk & Smith , 2001).



Source: study author

Fig. 1. Study area location.

The natural resource base of Vhembe biosphere includes three biomes (SAMABNC, 2014; Hahn, 2006): savannah, grassland and forest; four bioregions and twenty-three different vegetation types of biotopes (Dombo et al., 2006; Hahn, 2006; Mucina & Rutherford, 2006; Van Wyk et al., 2001). Eight of these biotopes are endemic to South Africa (Mucina & Rutherford, 2006). Vhembe biosphere is also a bio-geographical node, comprising the Kalahari, lowveld bioregions having temperate and tropical climatic conditions (UNESCO, 2017; Hahn, 2006). Based on Census 2011 Municipal report for Limpopo, 2012, the Vhembe biosphere has a relatively large and rapid growing human population of 1.5 million people (Stats SA, 2012) covering four local municipalities. Ninety-seven per cent of this population are rural residents with high unemployment rate (Stat SA, 2012) and obtain their livelihood on the limited natural resources in an unsustainable manner with differing impacts on land use and land cover change in the Vhembe biosphere. Despite substantial recognition that natural resources are changing due to land use activities, limited or no information is available on natural resource change in Vhembe biosphere and the surroundings.

Data description

This research paper used the South African National Land Cover (SANLC) 1990–1972 classes land cover data, with 70% accuracy, produced by GEOTERRAIMAGE obtained from Department of Environmental Affairs-GIS data (Thompson, 2019; https://egis.environment.gov.za/gis). This data was generated from digital, multi-seasonal Landsat 5 multispectral imagery acquired between 1989 and 1991 (Thompson, 2019).

In excess of 600 Landsat images were used to generate the land cover information, based on an average of 8 different seasonal image acquisition dates, within each of the 76× image frames required to cover South Africa (Thompson, 2019). The National Land Cover 2018 dataset was generated from 20 meter multi-seasonal Sentinel 2 satellite imagery. The imagery used represents the full temporal range of available imagery acquired by Sentinel 2. This data is widely used in South Africa for understanding the impact of land cover change on a variety of sectors. The accuracy of both maps is over 80%.

The SANLC 2018 dataset is based on the new land cover classification standard (SANS 19144-2) with 72 classes of information and is comparable with the previous 1990 and 2013–2014 South African National Land Cover (SANLC) datasets (Thompson, 2019). Use of the DEFF/DRDLR prescribed Albers Equal Area projection as the definitive map projection format for all change assessment and reporting was applied in the generation of 2018 land cover change for South Africa (Thompson, 2019; https://www.egis.environment.gov.za/gis/) Accessed 13 February 2020.

Data pre-processing

Key data to processing steps taken to generate the 1990/2018 and 2013/2014/2018 SANLC change assessment results was all geographic coordinate formats converted to SANLC datasets to the new, simplified land cover change legend format and content (Thompson, 2019).

Re-projection of the legend modified geographic coordinate for 1990, 2013/2014 and 2018 SANLC datasets to Albers Equal Area map projection was done, including a single-step spatial resampling for the SANLC 2018 dataset to a 30 × 30-m-cell resolution output.

During data processing, the study ensured that pixel-to-pixel registration between all 30-m-resolution Albers Equal Area map projection outcomes was done, using the 2018 SANLC as the reference dataset against which the 1990 and 2013/2014 datasets are registered. This approach was taken as the precision of the source Sentinel 2 imagery from which the SANLC 2018 was generated and considered superior to the Landsat imagery used in the compilation of the 1990 and 2013/2014 SANLC datasets. Pixel-level equivalent extent of land-cover geographic coverage between all SANLC datasets was done so that change assessment results do not include a null class in year-on-year assessments, due to differences in mapped land cover extents resulting from buffer zone mapping. Generation of a national 30-m resolution land-cover class-pair based change-reporting matrix for both 1990 vs 2018 and 2013/2014 vs 2018 change comparisons was done.

Methodology

For proper assessment of natural resource change in Vhembe biosphere, land cover change assessment was conducted using a 72 class national land cover dataset based on 30×30 raster cells for South Africa generated from multi-seasonal Landsat 5 imagery. The 72 class land cover map was re-classified to twelve classes (Table 1). Of the twelve classes, eight classes quantified in hectares: indigenous forests, thicket/dense bush, natural woodland, shrubland, grassland, water bodies and wetlands, categorised as vegetation natural resources for which the natural resource change assessment for this study was based. From eight categories, grassland was the major dominant natural resource followed by thicket/dense bush and shrubland. Water bodies and wetland natural resource had the least total coverage of the study area in hectares.

Table 1. Land cover classes for the study area: 1990, 2013 and 2018

The SANLC 72× class dataset re-classified to 12× classes or study area					
Reclas-sified classes	Class names (1990)	SANLC 1990 and 2013/2014 classes	Reclas-sified classes	Class names (2018)	SANLC 2018 classes
1	Indigenous forest	{4}	1	Indigenous forest	{1}
2	Thicket/dense bush	{5}	2	Thicket/dense bush	{2, 24)
3	Natural wood land	{6}	3	Natural woodland	{3, 4, 42, 43)
4	Planted forest	{32, 33, 34}	4	Planted forest	{5, 6, 7}
5	Shrubland	{9}	5	Shrubland	{8}
6	Grasslands	{7}	6	Grasslands	{12, 13}
7	Water bodies	{1, 2}	7	Water bodies	{14, 17, 18, 19, 20, 21}
8	Wetlands	{8}	8	Wetlands	{22, 23)
9	Barren land	{40, 41}	9	Barren land	{25, 26, 27, 30, 31}
11	Cultivated commercial	{10, 11, 12, 13, 14, 15, 16, 17, 18, 23, 24, 25}	11	Cultivated	{32, 38, 39, 40, 41, 42, 43, 44, 45, 46}
16	Built-up residential all	{42, 43, 44, 45, 46, 48, 49, 50, 51, 52, 57, 58, 59, 60, 61, 62, ,63, 64, 65, 66, 67, 68, 69, 70, 71, 72}	16	Built-up	{47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67}
20	Mines	35, 36, 37, 38, 39	20	Mines	{68, 69, 71, 72}

Land cover natural resource status maps of Vhembe biosphere for the period under study is given in Fig. 2, while natural resource change is analysed and discussed based on classes in Table 1.

Pre-processing of the acquired land cover data was conducted to ensure that the acquired data has similar and relevant projections clipped to the extent of the study area. Post-classification approach was used to detect and assess natural resource change in the study area based on statistical interpretation and analysis. Initially, the 1990–2018 land cover images were converted from Universal Transverse Mercator (UTM) to GCS_WGS_1984 ALBERS with a spatial resolution of 30m × 30m so that the data can be easily tabulated for change analysis. To identify percentage change of natural resource land cover change for study periods 1990, 2013 and 2018, a table was developed showing the land use land cover classes of the study area in hectares and then percentage change measured against each land cover land use classes for years 1990, 2013 and 2018. Percentage change to determine land cover and land use change was then calculated.

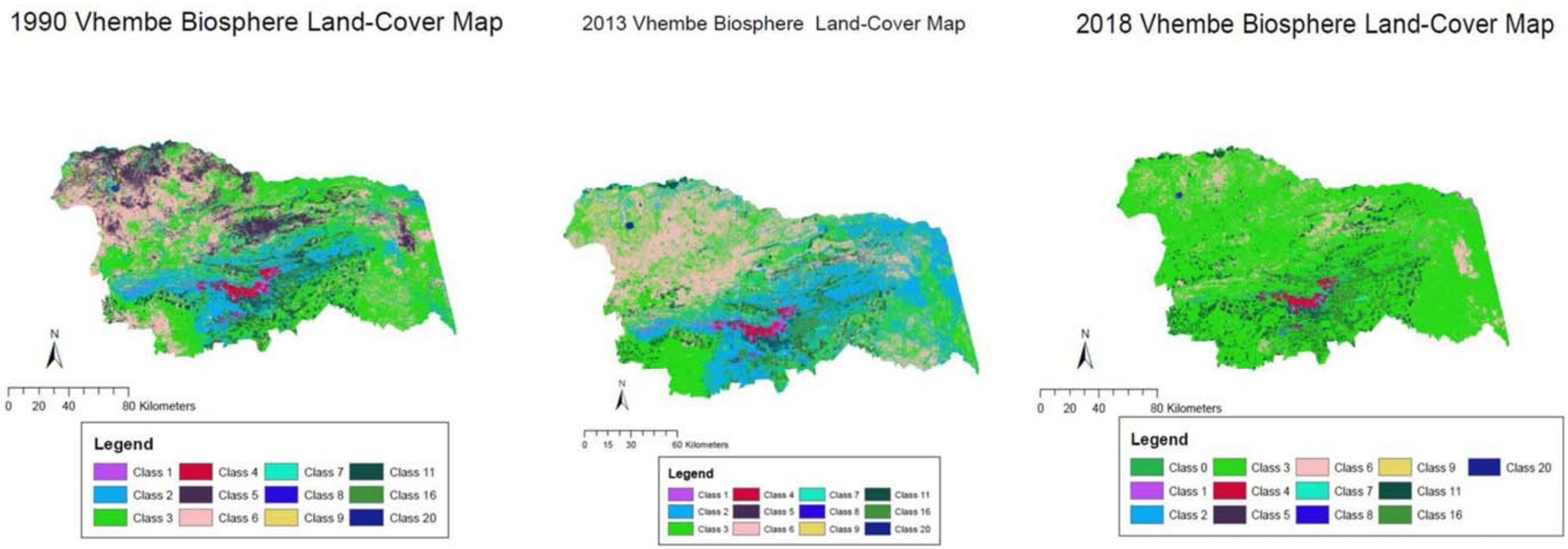


Fig. 2. Land cover natural resource status maps of Vhembe biosphere

To compare land cover–natural resource change, statistical analysis was used to calculate and quantify percentage of natural resource change between 1990, 2013 and 2018. To achieve this, the first task was to develop a table showing the area in hectares, and then percentage change for each year (1990, 2013 and 2018) was calculated against each land cover/natural resource type. Percentage change to determine the trend of change was then calculated by dividing the observed change by the earlier area (hectares) multiplied by 100. The basic procedures employed for data analysis and change detection are shown in Fig. 2.

Results

Harmonizing land cover classes for 1990, 2013 and 2018

For proper assessment of natural resource change in Vhembe biosphere, land cover change assessment was conducted using 72 classes land-cover data based on 30×30 raster cells for South Africa generated from multi-seasonal Landsat 5 imagery. The 72 class land cover map was re-classified to twelve classes (Table 1). Of the twelve classes, eight classes quantified in hectares: indigenous forests, thicket/dense bush, natural woodland, shrubland, grassland, water bodies and wetlands, categorised as vegetation natural resources for which the natural resource change assessment for this study was based. From eight categories, grassland was the major dominant natural resource followed by thicket/dense bush and shrubland. Water bodies and wetland natural resources had the least total coverage of the study area in hectares. Land cover natural resource status maps of Vhembe biosphere for the period under study is given in Fig. 3, while natural resource change is analysed and discussed based on classes in Table 1.

Table 2. Natural resource distribution (ha) in the study area: 1990, 2013 and 2018

Natural resource share in hectares/%age	1990	1990	2013	2013	Hectares 2018	2018
Indigenous forest	13,211.91 (ha)	1%	16,880.49 (ha)	5%	7402.92 (ha)	1%
Thicket/dense bush	338,723.73 (ha)	22%	63,569.34 (ha)	20%	23,166.92 (ha)	2%
Natural wood land	94,665.42 (ha)	6%	81,755.37 (ha)	26%	257,889.68 (ha)	21%
Planted forest	28,896.12	2%	23,124.24 (ha)	7%	35,460.12 (ha)	3%
Shrubland	263,070.63 (ha)	17%	19,685.43 (ha)	6%	977.72 (ha)	0%
Grasslands	562,136.49 (ha)	37%	64,506.6 (ha)	20%	326,498.96 (ha)	27%
Water bodies	2719.44 (ha)	0%	4483.71 (ha)	1%	8953.64 (ha)	1%
Wetlands	5788.8 (ha)	0%	1125.27 (ha)	0%	3561.04 (ha)	0%
Barren land	16,803.09 (ha)	1%	20,340.99	6%	24,971.92 (ha)	2%
Cultivated commercial	132,246.9 (ha)	9%	10,846.8 (ha)	3%	365,644.92 (ha)	30%
Built-up residential all	74,070.27 (ha)	5%	9220.14 (ha)	3%	147,701.88 (ha)	12%
Mines	3447.09 (ha)	0%	3183.48 (ha)	1%	2497.96 (ha)	0%
Totals	1,535,779.89 (ha)	100%	318,721.86 (ha)	100%	1,204,727.68 (ha)	100%

Natural resource cover maps and statistics

For natural resource area coverage in the study area, grasslands occupied the largest area in 1990 with 562,136.49 ha, while in 2013, natural woodland was the dominant natural resource land cover with 81,755,37 ha. In contrast, shrubland natural resource cover reduced in hectares significantly from 263,070.63 ha in 1990 to 19,685.43 ha in 2013 and 977.7 in 2018. Of interest to note is the indigenous forestland natural resource cover, which increased from 13,211.91 in 1990 to 16,880.49 ha in 2013 and declined sharply in 2018 to 7,402.92 ha.

Natural resource land cover distribution in hectares and percentages for each year is presented in Table 2 and Figs. 2 and 3.

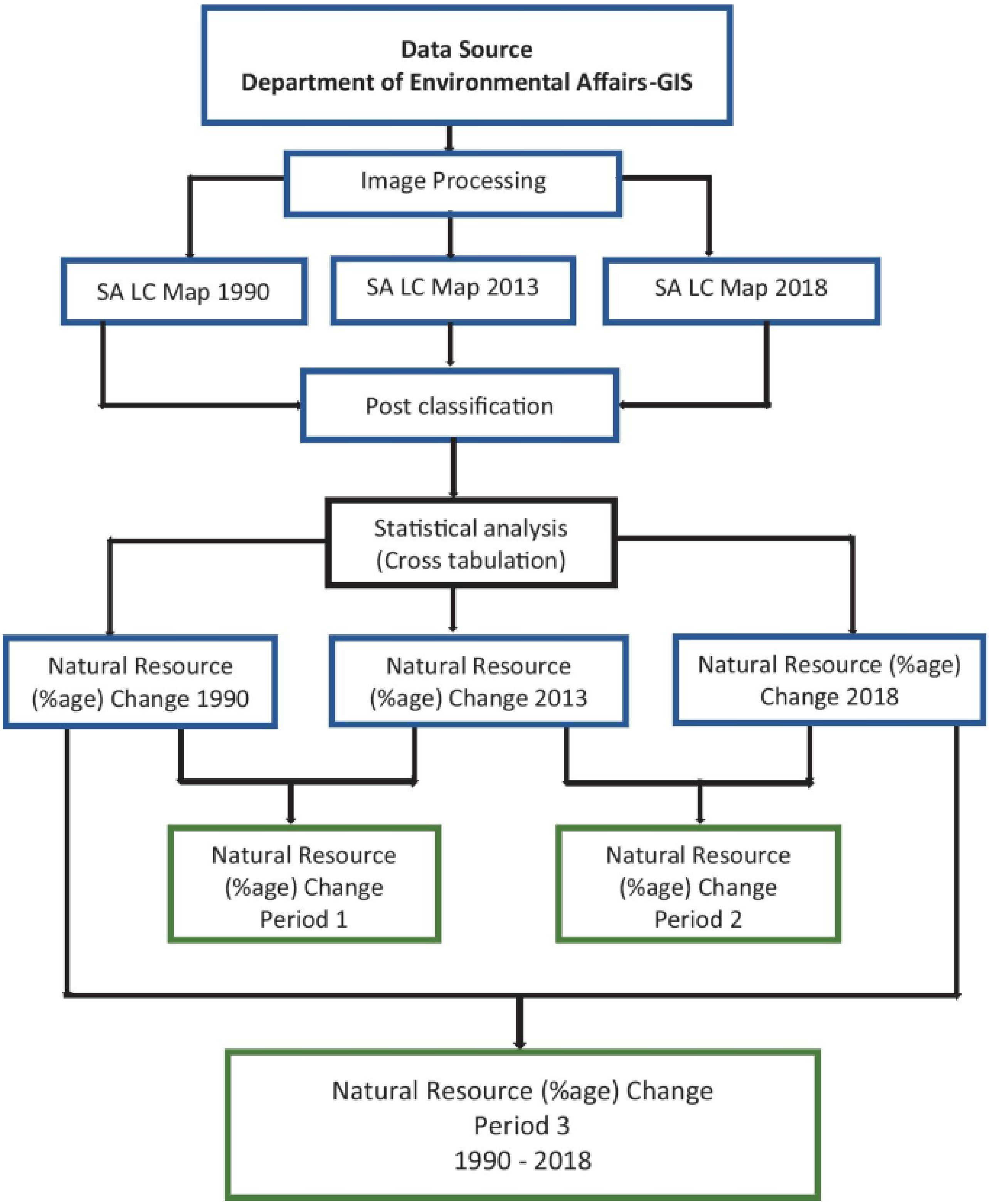


Fig. 3. Steps taken to detect natural resource change

Natural resource change between 1990 and 2013/2014

Natural resource change assessment based on land cover change in the study area, for 1990 and 2013, indicate that in 1990, grassland natural resource which was the dominant land cover in Vhembe biosphere, with a total land cover area of 562,136.5 (ha), decreased to 64,506.6 (ha) in 2013, an equivalent of −89% change in natural resource area coverage (Table 3; Figs. 4 and 5).

Table 3. Land cover natural resource change in hectares (ha) and percentages (%ages) 1990–2013/2014

Land cover–natural resource	1990	2013	Hectares change	%age change
Indigenous forest	13,211.91 (ha)	16,880.49 (ha)	3668.58 (ha)	28%
Thicket/dense bush	338,723.7 (ha)	63,569.34 (ha)	−275,154.39 (ha)	**−81%**
Natural woodland	94,665.42 (ha)	81,755.37 (ha)	−12,910.05 (ha)	−14%
Planted forest	28,896.12 (ha)	23,124.24 (ha)	−5771.88 (ha)	−20%
Shrubland	263,070.6 (ha)	19,685.43 (ha)	−243,385.2 (ha)	**−93%**
Grasslands	562,136.5 (ha)	64,506.6 (ha)	−497,629.89 (ha)	−89%
Water bodies	2719.44 (ha)	4483.71 (ha)	1 764.27 (ha)	65%
Wetlands	5788.8 (ha)	1125.27 (ha)	−4663.53 (ha)	−81%
Barren land	16,803.09 (ha)	20,340.99 (ha)	3537.9 (ha)	21%
Cultivated commercial	132,246.9 (ha)	10,846.8 (ha)	−121,400.1 (ha)	−92%
Built-up residential all	74,070.27 (ha)	9220.14 (ha)	−64,850.13 (ha)	−88%
Mines	3447.09 (ha)	3183.48 (ha)	−263.61 (ha)	−8%

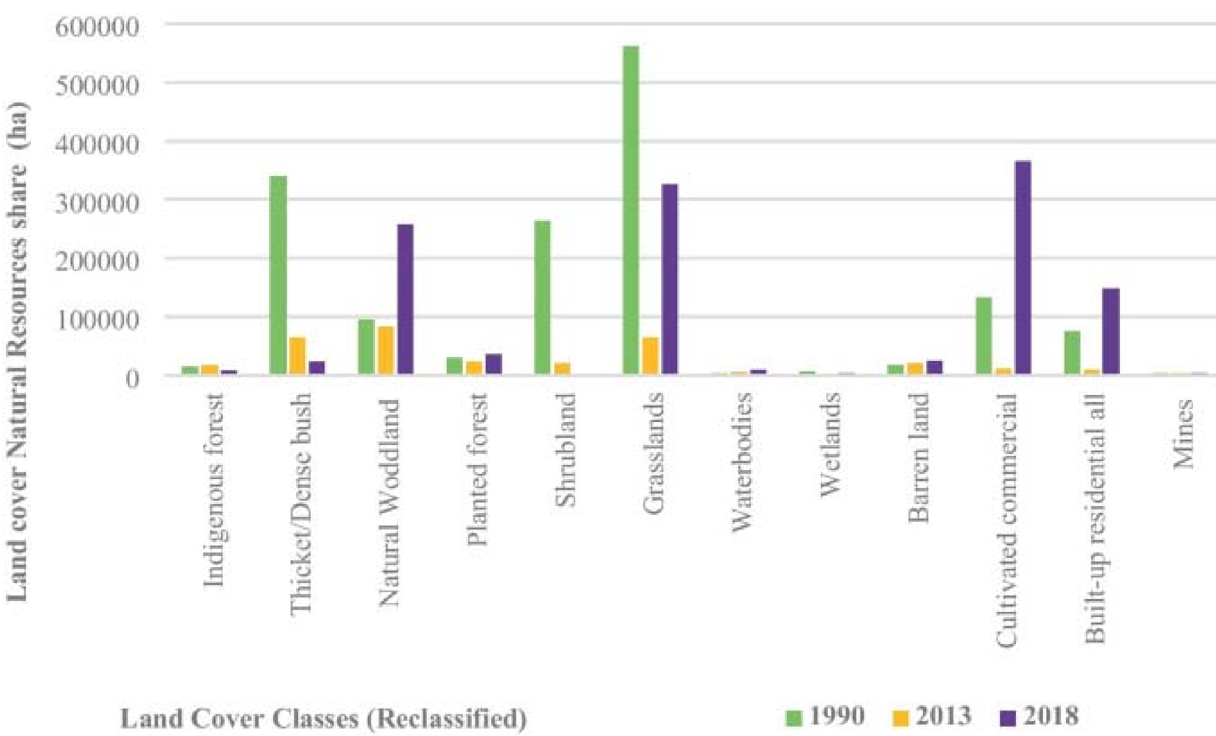


Fig. 4. Land cover and natural resource class status (%) for 1990, 2013 and 2018

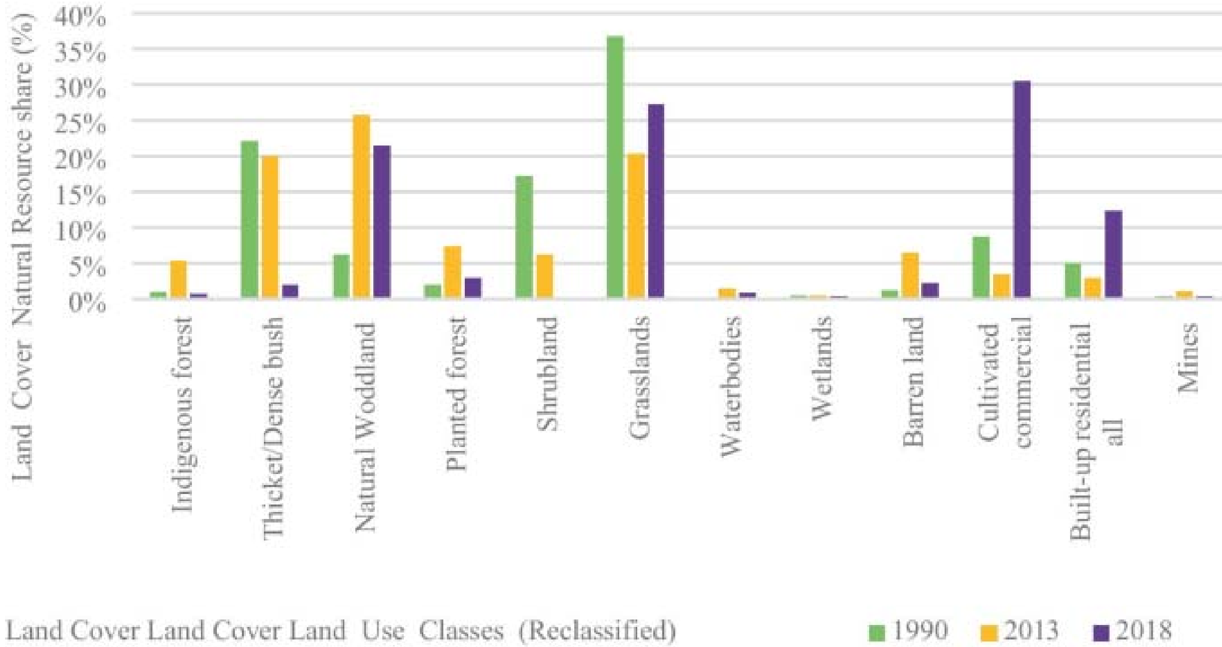


Fig. 5. Percentage share of land cover–natural resource for 1990, 2013 and 2018

It is also noticed that thicket/dense bush and shrubland resources decreased from 338,723.7 and 263,070.6 (ha) in 1990 to 63,569.34 and 19,685.43(ha) in 2013 at −81% and −93% change respectively. It is anticipated that the three natural resources registered a significant decrease, presumably due to relevant anthropogenic activities like building of residential areas and commercial farming to non-anthropogenic factors like fluctuations in climate and temperature in the study area.

Natural resource change between 2013 and 2018

In 2013, thicket dense bush natural resource decreased from 63,569.34 to 23,166.92 ha in 2018, a −6% decrease (Table 4; Figs. 6 and 7). This was followed by shrubland that decreased from 19,685.43 to 977.72 ha with a percentage change of −9%. It is interesting to note that while a decrease in shrubland cover natural resource was registered in the study area, for this period, cultivated commercial land and built-up residential area registered a drastic increase, as a land cover land use. Cultivated commercial area increased from 10,846.8 ha in 2013 to 365,644.9 ha in 2018 with a percentage change of 294%; built-up area from 9220.4 ha in 2013 to 147,709.9 ha in 2018 with a percentage change increase of 135% respectively. It can be assumed that shrubland natural resource decreased at the expense of increased activities in cultivated commercial and build-up residential land cover (Figs. 8 and 9).

Table 4. Land cover natural resource change (ha) and in percentages (%ages) 2013–2018

Land cover natural resource change in hectares (ha) and percentages (%ages)

Land cover land use classes	2013	2018	Change (hectares)	%age change
Indigenous forest	16,880.49 (ha)	7402.92 (ha)	−9477.57 (ha)	−5%
Thicket/dense bush	63,569.34 (ha)	23,166.92 (ha)	−40,402.42 (ha)	−6%
Natural wood land	81,755.37 (ha)	257,889.68 (ha)	176,134.31 (ha)	19%
Planted forest	23,124.24 (ha)	35,460.12 (ha)	12,335.88 (ha)	5%
Shrubland	19,685.43 (ha)	977.72 (ha)	−18,707.71 (ha)	−9%
Grasslands	64,506.6 (ha)	326,498.96 (ha)	261,992.36 (ha)	37%
Water bodies	4483.71 (ha)	8953.64 (ha)	4469.93 (ha)	9%
Wetlands	1125.27 (ha)	3561.04 (ha)	2435.77 (ha)	19%
Barren land	20,340.99 (ha)	24,971.92 (ha)	4630.93 (ha)	2%
Cultivated commercial	**10,846.8** (ha)	**365,644.92** (ha)	**354,798.12** (ha)	**294%**
Built-up residential all	**9220.14** (ha)	**147,701.88** (ha)	**138,481.74** (ha)	**135%**
Mines	3183.48 (ha)	2497.96 (ha)	−685.52 (ha)	−2%

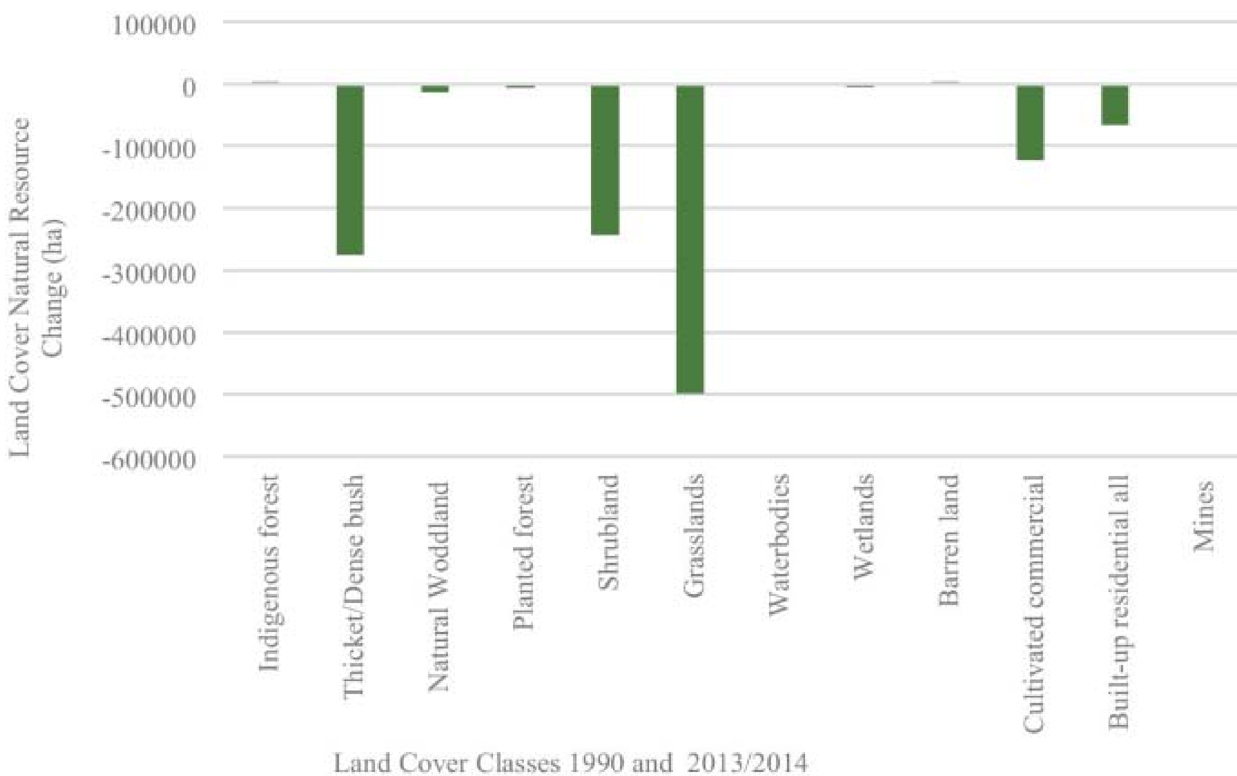


Fig. 6. Change in land cover and land use of the study area from 1990 to 2013

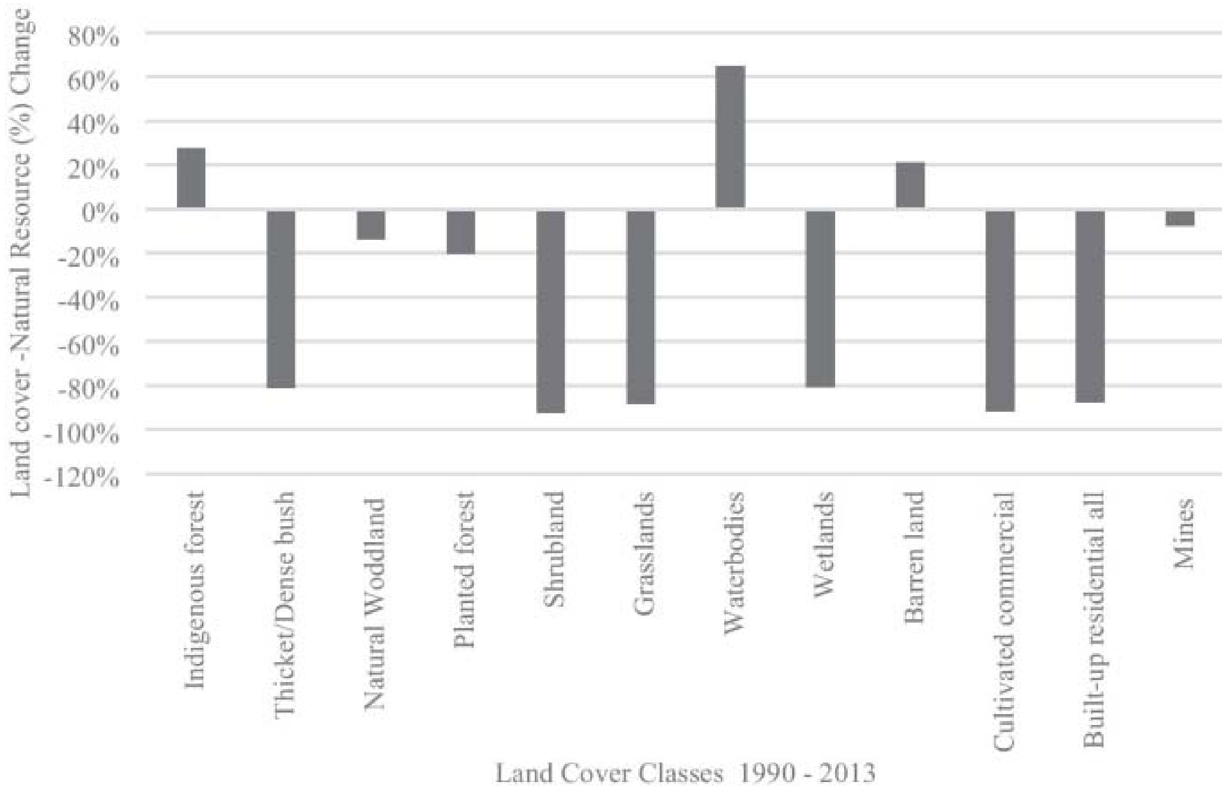


Fig. 7. Change in land cover and land use of the study area from 1990 to 2013

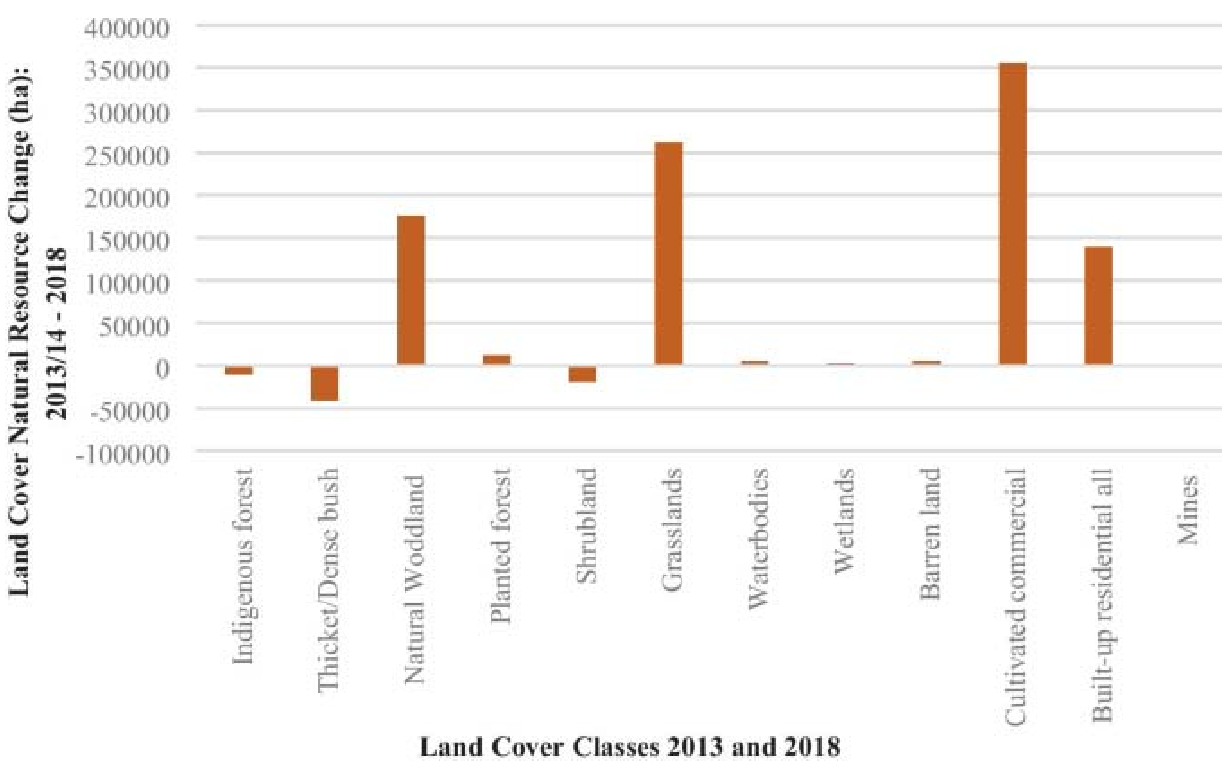


Fig. 8. Change in land cover and land use of the study area from 2013 to 2018

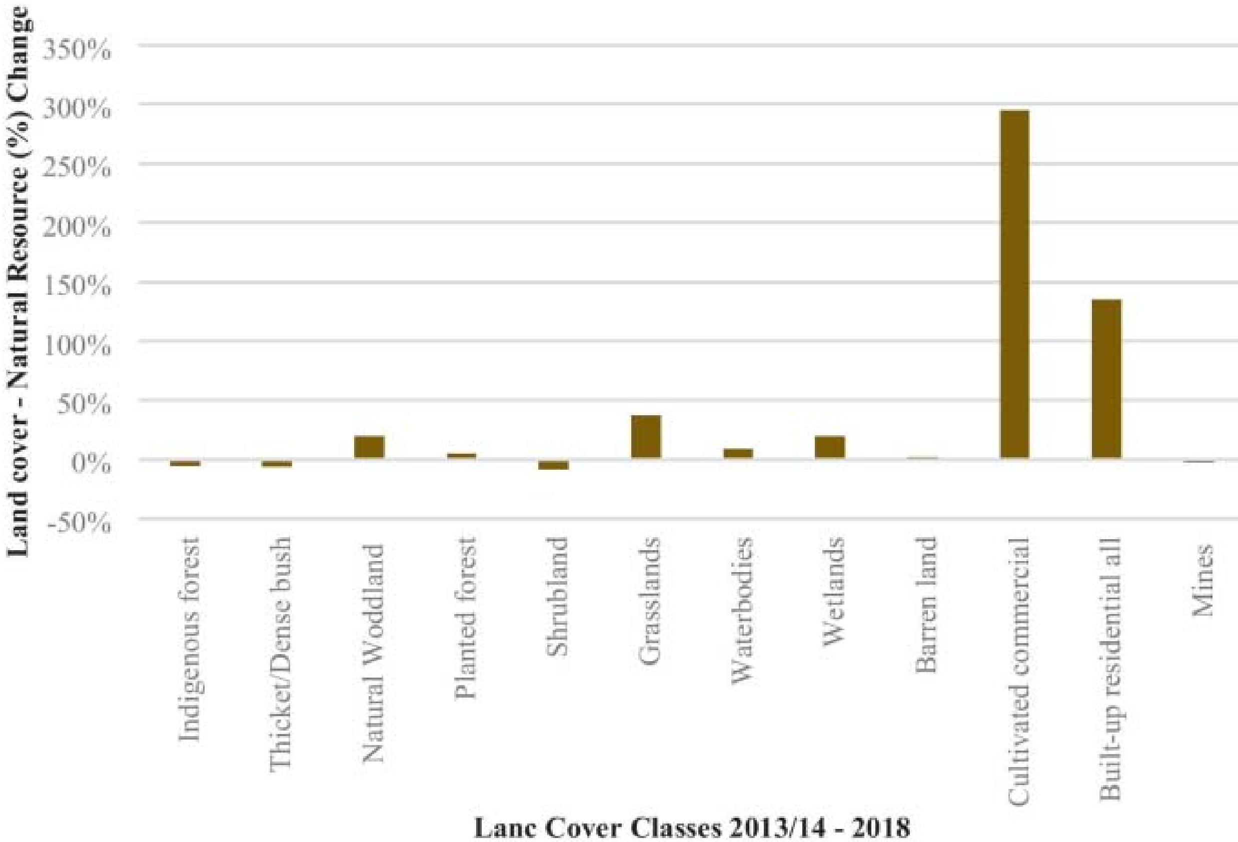


Fig. 9. Change in land cover and land use of the study area from 2013/2014 to 2018

Natural resource change between 1990 and 2018

Observed natural resource class change analysed for three classes: thicket/dense bush, shrub-land and grass land, between 1990 and 2018, indicate that thicket/dense bush resources decreased from 338,723.73 (ha) in 1990 to 23,166.92 (ha) in 2018 by −315,556.81 (ha), a percentage change decrease of −96%, while shrubland natural resource decreased from 263,070.63 (ha) in 1990 to 977.72 (ha) in 2018 by −262,092.91 (ha), a percentage change decrease of −100%, and grassland natural resource decreased from 562,136.49 (ha) in 1990 to 326,498.96 (ha), a percentage change decrease of −42% in 2018. Cultivated commercial area between 1990 and 2018 increased in hectarage from 132,246.9 (ha) in 1990 to 365,644.9 (ha) in 2018, a percentage change increase of 176%. Built-up residential area increased in hectarage from 74,070.27 (ha) in 1990 to 147,701.88 (ha) in 2018 with a percentage change increase of 99% respectively. The observed changes (hectarage and percentage) in natural resource for cultivated commercial area and built-up residential area can be attributed to encroachment of man’s activities on other natural resources like shrubland, grasslands, natural wood land and indigenous forests in the study area (Figs. 10 and 11).

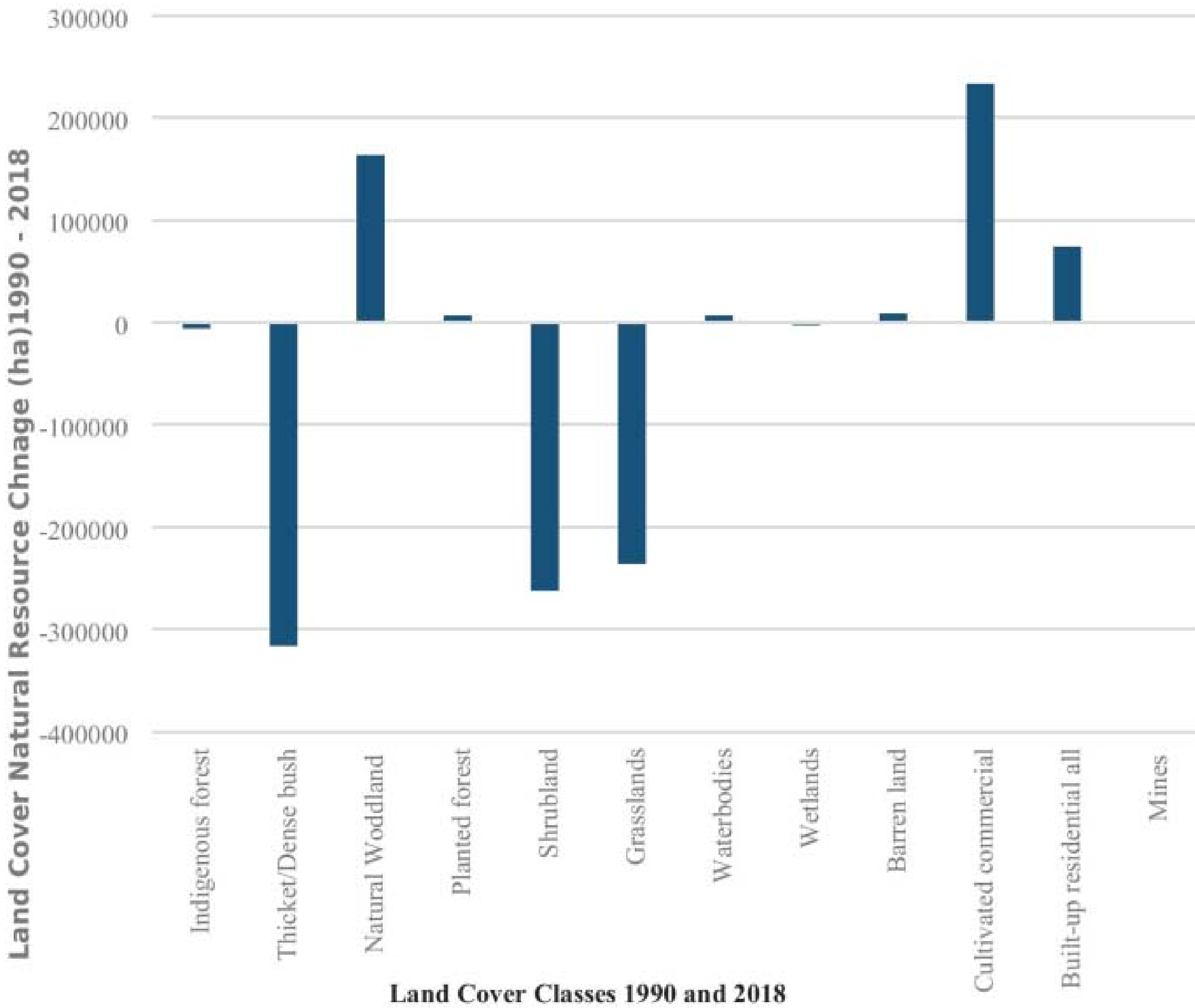


Fig. 10. Change in land cover and land use of the study area from 1990 to 2018

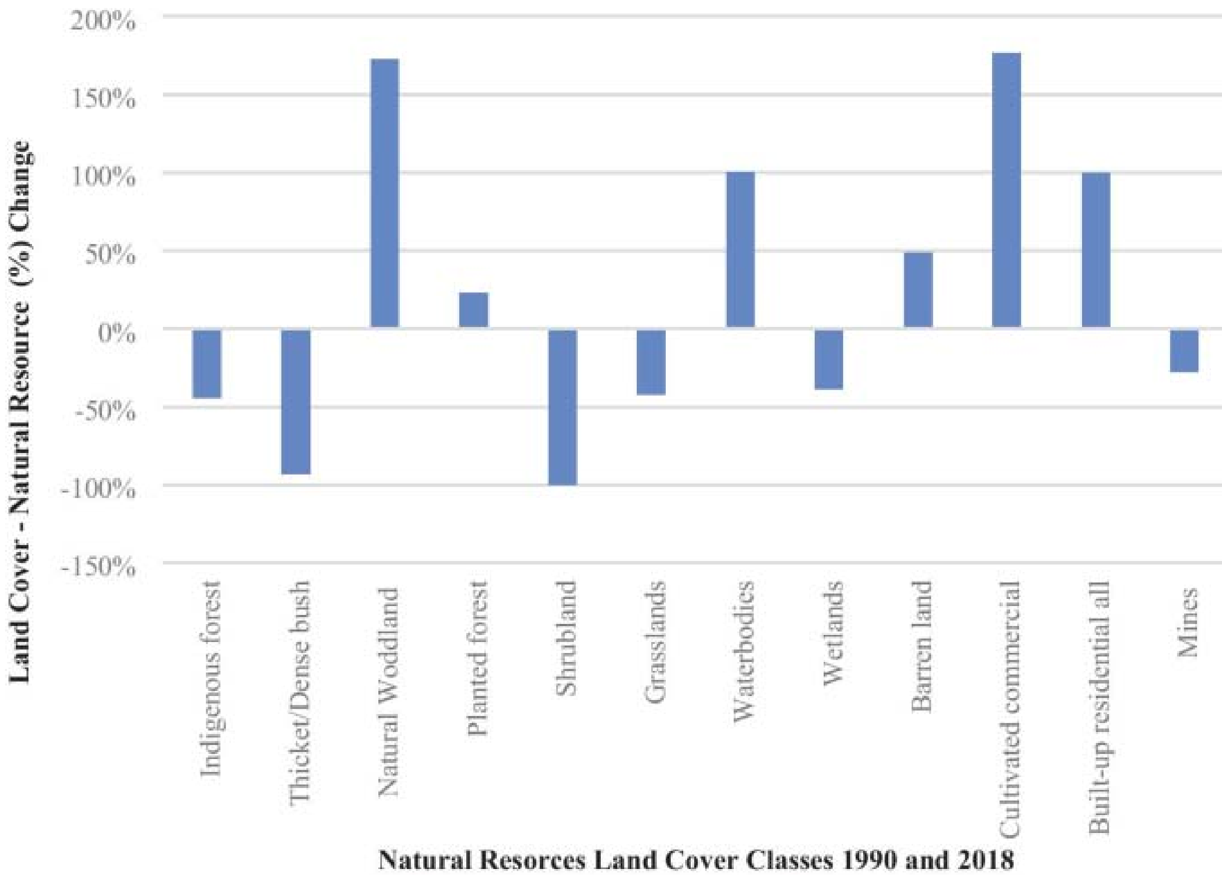


Fig. 11. Change in land cover and land use of the study area from 1990 to 2018

Discussion

Natural resource change driven by human activities and natural factors observed around the world has increasingly contributed to global loss of native biodiversity and the alteration of ecological processes and services across different ecosystems in different parts of the world (Msofe et al., 2019). Land use and its related activities in Vhembe biosphere have a direct influence on natural resource change. Using thicket/dense bush land cover class as an example, there was a significant reduction in its area size from 338,727 (ha) in 1990 to 63,569 (ha) in 2013, an indication of human activity encroachment on the natural resource. Likewise, natural woodland reduced drastically by −12,910 (ha) from 94,665 (ha) in 1990 to 81,755 (ha) in 2013. The sharp reduction of natural woodland registered in this period followed by an increase of barren land from 16,803 (ha) in 1990 to 20,340 (ha) in 2013 presupposes increased human activities that could have contributed to the clearance of such a natural resource in search of human survival.

Decrease in grassland resource area cover by −497,627 (ha) from 562,136 (ha) in 1990 to 64,506 in 2013 in the study area could be an indication of the importance attributed to utilisation of grassland natural resources by man, like livestock grazing, crop husbandry and other functions they provide for man survival.

This also suggests that climatic variation could be having negative impacts on grassland natural resource, which could significantly be higher than man-induced activities on natural grassland. In this study, we also analysed that shrubland natural resource had a steady decline in land use land cover from 263,070 (ha) in 1990 to 19,685 (ha) in 2013, and the decline continued to 977 (ha) in 2018 with total natural resource decline change of −262,092 (ha) respectively.

This sharp decline over the study period could be attributed to the biotic disturbance in which shrubland struggles to grow or can no longer exist on a piece of land due to anthropogenic causes like livestock grazing and non-anthropogenic causes like climate variation over the study period.

Further data analysis and observation of why the erratic decrease in shrubland and grassland natural resource cover and usage in the study area indicate that planted forests could have encroached on both shrubland and grassland natural resource cover, as planted forest size in hectares increased from 28,896.12 (ha) in 1990 to 35,460.12 (ha) in 2018.

Natural woodland resource cover increased by 163,224.26 (ha) from 94,665.42 (ha) in 1990 to 257,889.68 (ha) in 2018; this could be another contributing factor to the decrease in shrubland and grassland natural resource coverage in the study area.

Results also indicate that human-induced land use and land cover activities like cultivated commercial activities were at a downward trend in land use land cover from 132,246 (ha) in 1990 to 10,846 (ha) in 2013 but increased substantially from 10,846 (ha) in 2013 to 365,644 (ha) in 2018. This is assumed as an indication of how land use activities have contributed to natural resource land cover change in the study area.

Important to consider is that natural resources that could have changed due to increase in cultivated land should be investigated further to understand the driver and consequences behind such a change in the study area. The observed decrease in land cover natural resources above could be attributed to increased land use demand for commercial farming and urban development as indicated by an erratic increase of cultivated commercial land cover use from 132,246.9 (ha) in 1990 to 365,644.92 ha by 233,398 (ha) and built-up residential land cover use increase from 74,070.27 (ha) in 1990 to 147,701.88 (ha) in 2018 by 73,631.61 (ha) as indicated in Table 5.

Table 5. Land cover natural resource change (ha) 1990–2018

Land cover land use classes	1990	2018	Change (ha)	%age change
Indigenous forest	13,211.91 (ha)	7402.92 (ha)	−5808.99 (ha)	−44%
Thicket/dense bush	338,723.7 (ha)	23,166.92 (ha)	−315,556.81 (ha)	−93%
Natural wood land	94,665.42 (ha)	257,889.68 (ha)	163,224.26 (ha)	172%
Planted forest	28,896.12 (ha)	35,460.12 (ha)	6564 (ha)	23%
Shrubland	263,070.6 (ha)	977.72 (ha)	−262,092.91 (ha)	−100%
Grasslands	562,136.5 (ha)	326,498.96 (ha)	−235,637.53 (ha)	−42%
Water bodies	2719.44 (ha)	8953.64 (ha)	6234.2 (ha)	21%
Wetlands	5788.8 (ha)	3561.04 (ha)	−2227.76 (ha)	−38%
Barren land	16,803.09 (ha)	24,971.92 (ha)	8168.83 (ha)	49%
Cultivated commercial	132,246.9 (ha)	365,644.92 (ha)	233,398.02 (ha)	176%
Built-up residential all	74,070.27 (ha)	147,701.88 (ha)	73,631.61 (ha)	99%
Mines	3447.09 (ha)	2497.96 (ha)	−949.13 (ha)	−28%

Studies conducted on the impact of land use land cover changes on natural resource (Munthali et al., 2020) assessment of land use impact on natural resources (Dale et al., 1998) and evaluation of ecosystem service and trade off (Arunyawat & Shrestha, 2016) using a combination of approaches like remote sensing, household surveys, focus group discussions and GIS with computer models that simulate changes in land cover and land use impact (Munthali et al., 2020; Dale et al., 1998) concluded that land use land cover changes have led to significant decline in ecosystems, forest cover and agricultural land. In this study, remote sensing and statistical analysis used to assess the drivers of natural resource change in Vhembe biosphere concluded that specific natural resources like shrubland, indigenous forests and wetlands declined in area size (hectarage) due to natural resource uses in the form of urban development, agriculture, plantation farming, mining and animal husbandry.

In summary, in order to meet developmental and associated requirement, like construction materials and food supply, cultivated land and natural wood plantations have increased at the expense of other vegetation natural resources such as indigenous forest, natural wood land, thicket/dense bush, shrubland and barren land in the study area, in which majority of inhabitants depend on the entire Vhembe biosphere resources for their daily survival. Alterations of natural resources to accommodate man's developmental activities like settlement, urbanisation and commercial cultivation as identified have potential negative conservation implications on natural resources in the study area, either direct or indirect, including biodiversity loss natural resource degradation, pollution and deforestation.

Conclusions

Natural resource changes in a given environment are interplay of man's activities and natural causes. In the case of Vhembe biosphere, natural resource uses in the form of urban development, agriculture, plantation farming, mining, animal husbandry and natural wood land encroachment contributed to decline of different types of natural and biosphere resource. The noticed significant decline in shrubland, grassland and thicket/dense bush due to potential encroachment by other natural vegetation resources and man's activities presents an opportunity to explore further the drives of such natural changes and their relevant impact.

Other contributing factors to natural resource change could have been climate patterns that influence the intensity as well as the rate of natural resource change. An assessment of the drivers of natural resource change in the Vhembe biosphere should be undertaken to fully understand the causes behind irreversible natural resource change of the biosphere.

Ethics declarations

Conflict of interest

The authors declare no competing interests.

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