Research Article

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An Assessment of the Factors Responsible for the Extent of Deforestation in Mapfungautsi Forest, Zimbabwe

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ABSTRACT

This study was conducted in Mapfungautsi forest to determine the extent of deforestation from the year 2000 (when no deforestation was detected by satellite imagery) up to 2020, as well as to gather perspectives from members of communities around the forest, on factors responsible for deforestation. A mixed method approach in the form of remote sensing techniques, questionnaires and key informant interviews was used to gather data. Findings indicated the extent of deforestation to be 4254ha (5%) and 10632ha (14%) after the first decade (2000 – 2010) and second decade (2000 – 2020) respectively. ***Of the cleared forest, the most affected vegetation cover type was the wooded grassland (84%) followed by bushland (31%) and wooded land (10%) after the 20-year period. Respondents identified political gain, expansion of jurisdictions of chiefs and population pressure as the social factors most responsible for accelerated deforestation in Mapfungautsi. Conversely, the identified economic factors mainly contributing to deforestation were agriculture, timber and firewood poaching. The study concluded that agriculture was the single most impactful factor responsible for deforestation as the main social factors (political gain and expansion of chieftaincy) worked in combination to invade and clear protected forests for settlement and agriculture (which is also the main livelihood source of local people). Consequently, any control measures to arrest deforestation in Mapfungautsi and any other protected forests for that matter, will require serious buy-in and will power from political and traditional leaders and other stakeholders like farmers and community members.***

Keywords

Deforestation, Agriculture, Protected forest, Economic factors, Social factors.

Introduction

Zimbabwe's natural forests have been reduced considerably due to population pressure. A significant decrease of forest cover has been witnessed in the past three decades, triggering interests in conducting researches on land use, land cover changes and understanding the drivers of the forest cover loss. Estimations are that by the year 2001, Zimbabwe had lost its forest cover to 60 % and in several heavily populated districts the forest cover was at 30% [1]. Similarly, Gotore et al. [2], posits that Zimbabwe lost an average of 312 900ha per year during the 1990-2000 decade. The trend worsened between the year 2000 to 2005, where the rate of deforestation increased by 16.4% to 1.64 per year [2]. The major cause of this forest cover reduction was extension of agricultural land into traditional protected forest areas. This problem has not been peculiar to Zimbabwe as estimates by FAO indicate that countries in the tropics lost their forest cover to anthropogenic activities by 24 million ha between 1999 and 2000 [3]. Identified major drivers of the forest cover loss is poverty which is forcing people to invade into forested land to practice slush and burn agriculture system for subsistence farming [3-5]. Forest cover loss is in two ways, which is deforestation and forest degradation. According to Tejaswi [3], deforestation can be defined as converting

a forest land to another land use and when the tree cover become less than 10%. Deforestation is dissimilar from forest degradation in the sense that degradation is declining or depletion of the forest in terms of stem density or structure of vegetation cover including species composition [6], and the consequence is reduced forest productivity.

Progressively over the past decades, the forest cover loss or deforestation brought the global concern about the carbon stock depletion and emissions since the forests are on the international climate change agenda because of their ability to accumulate and store large amounts of carbon. Deforestation activities including clearing of forested land for agriculture and other activities contributed to an estimation of one third of the total anthropogenic emissions of carbon in the past 150 years [7]. Zimbabwe is a signatory to the UNFCCC and has been making efforts to reduce emissions from deforestation however competing land use systems such as agriculture and settlements makes it difficult. Mapfungautsi forest is one of the protected forests that has been significantly reduced due to proliferation of human settlements and has a total of 1950 families according to local Forestry Commission of Zimbabwe officials. It is therefore very important to investigate factors contributing to deforestation of the natural forests and woodlands and put in place strategies of monitoring the rate and extent of deforestation. Further, it is critical to gather facts from communities surrounding the forest and other stakeholders on the main factors contributing to deforestation. Knowledge of the extent of deforestation and factors responsible for accelerated forest loss is critical for relevant government ministries and departments to enable informed decision making on developing strategies to mitigate deforestation.

Methods

Study area description

The study was conducted in Mafungautsi forest situated in Gokwe South district, in the Midlands province of Zimbabwe. The northern boundary of the forest is Sengwa River from Bomba Business centre to the east up to Nkayi road (Figure 1). The western boundary is mainly imaginary except for a portion where Nkayi road is part of the boundary (Figure 1). The southern boundary of the forest is also imaginary and forms part of Midlands and Matabeleland North province boundary. The eastern boundary is imaginary up to Kwekwe road. Kwekwe road forms part of the eastern boundary up to Bomba business centre.

The majority of Mapfungautsi forest lies within agro-ecological region III with some few portions on the southern part in agro-ecological region IV as classified by Vincent and Thomas [8]. The average rainfall quantity per annum for agro-ecological region III ranges from 650mm to 850mm while mean temperature for the region ranges from 18^0 C to 22^0 C. The few portions on the southern part of the forest which fall under agro-ecological region IV receive annual rainfall ranging from 450mm - 650mm and is characterized by mean temperatures ranging from 18^0 C to 24^0 C [8].

Mapfungautsi forest is a deep Kalahari sand (Aeolian) plateau that stretches for 40km from the western boundary to the eastern one. The plateau is a source for four rivers namely; Sengwa, Lutope, Mbumbusi and Ngondoma, with Ngondoma extending to the western side in the opposite direction of the other three rivers. The three rivers dissect Mapfungautsi forest into a ridge and furrow landform, with Kalahari sands forming the ridges and the rivers forming the furrows. This arrangement created some wide undulations across the forest resulting in distinct vegetation differences in ridges and furrows.

The vegetation of the forest area is dominated by the Zambezi teak *Baikiaea plurijuga*, *Pterocarpus angolensis*, *Brachystegia spiciformis* and *Julbernadia globiflora* on the Kalahari sand ridges and slopes, and *Terminalia* species on the lowlands/furrows. The forest is three strata and mature in undisturbed portions, with *Baikiaea plurijuga*, *Brachystegia spiciformis*, *Julbernadia globiflora*, *ricinodendron rautanenii* forming the canopy. The middle layer is comprised of some middle-aged trees of the same species. The bottom layer comprise of grasses, regenerating saplings of the same species of the middle and upper layers. Very deep inherently infertile sands classified as Regosols dominate the entire area especially of uplands, crests and slopes. In low-lying sites however are soils with a higher content of clay and organic matter. Presumably, these soils are greyish to darkish, fertile and have a higher water holding capacity

The land use system in Mapfungautsi was initially a forestland use with some utilization of timber and non-timber resources. Selective timber logging was done on several occasion in 1980s and 1990s. Around 2002 salvaging of timber was done but only for a few months. The land use system later on changed with the introduction of human settlements soon after the year 2000 where agriculture activities were introduced. The agricultural system mainly practiced is slash and burn, which has accelerated vegetation loss in the past two decades. There are three settlements namely; Zanda, Ngoma and Sengwa-Muzola with a total of 1940 homesteads.

The major economic activity within the forest area is agriculture which is being practised by the forest settlers and the main crop produced is maize (staple food for Zimbabwe). A few settlers also practice mixed farming comprising both crop and livestock production. Villages within the Mapfungautsi forest are led by a village chairperson and kraal heads appointed by the Chief. However, the social structure is not in the records of local government because forest area has not been de-gazetted for settlements. No social service facilities are in place except one primary school (Ngondoma Primary School) which was built in 2010.

Data Collection

A mixed method approach was employed to solicit data in the study. Remote sensing techniques were employed to gather quantitative data while qualitative data were collected using open-ended questionnaires and key informant interviews. These three data collection tools are discuss in greater detail below:

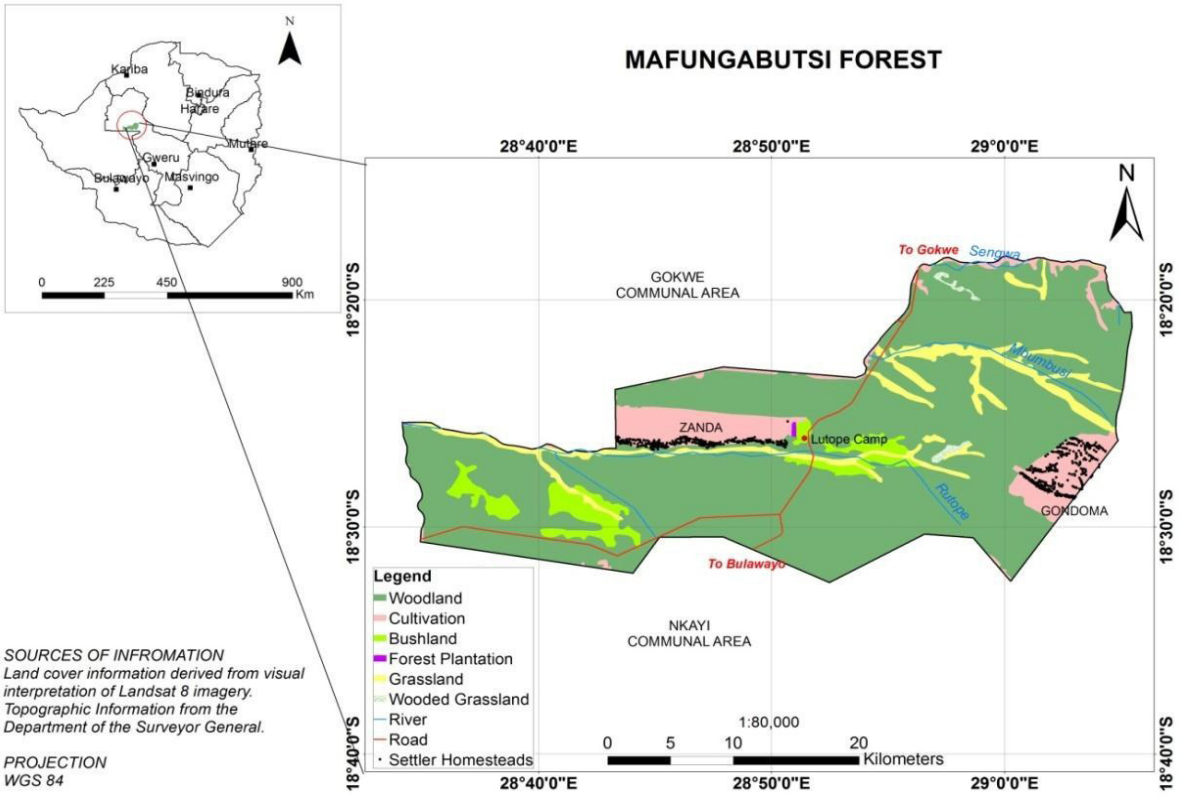

Figure 1: Map of the study area

Remote sensing

Remote sensing is a technique which has been very helpful in monitoring forest cover and estimating deforestation. As noted by Brown et al. [9] and Akingbogun et al. [10], areas of deforestation are visible from space and can be easily mapped at a range of landscape scales. A range of remote sensing data have been used in determining the extent of deforestation and these include both passive and active sensors such as LIDAR, MODIS, Landsat, IRS LISS III, etc. Similarly, the extent of deforestation in this study was determined by using USGS downloaded satellite images from Landsat 4, 5 and 8. Table 1 indicates date of image acquisition and type of sensor used to generate the images.

Table 1: Date for satellite image acquisition.

Year	Date of acquisition	Satellite	Sensor
2000	15 October 2000	Landsat 4-5Landsat	Thematic Mapper
2010	09 November 2010	Landsat 4-5	Thematic Mapper
2020	05 November 2020	Landsat 8	Operational Land Imager/ Thermal Infrared Sensor

The forest area affected by settlements and cultivation was calculated using ArcGIS image classification technique whereby training sites under forest cover were used to calculate the forest cover area. The same was done to calculate cultivated area. Forest cover maps for Mapfungautsi forest were used to determine the extent of deforestation for 20 years, from the year 2000 to 2020. The extent of deforestation was measured at ten year intervals.

Questionnaire

Gathering of perceptions from the public and or a targeted group of people can be done using a set of questions which may be of open ended or closed ended nature. Drivers of deforestation in Mapfungautsi forest area were established through use of a questionnaire with both open ended and closed set of questions. The advantage of using both opened ended and closed ended questions is to guide the respondent and also allow views 'outside the box'. A total of 50 questionnaires were randomly distributed to members of the community residing adjacent to the forest and have knowledge of factors responsible for deforestation.

Key informant interviews

A total of 15 key informant interviews were conducted with local stakeholders from government, Zimbabwe Parks and Wildlife Authority, Gokwe South Rural District Council and Zimbabwe National Water Authority (ZINWA) to corroborate data gathered from the questionnaires. Similar questions to the one included in questionnaires were included on the interview guide.

Both the questionnaire and the key informant interview guide had two sections; one for social factors and the other for economic factors responsible for deforestation. Each factor's contribution to deforestation, irrespective of whether it falls under social or economic, was assessed by respondents using a scale given in Table 2.

Table 2: Scale indicating the severity/contribution to deforestation.

Factor scale	Description
1	low contribution to deforestation
2	moderately contribute to deforestation
3	highly contribute to deforestation

Factor weights for each of the factors mentioned or suggested by respondents were then calculated as follows:

Factor weight = Number of Respondents x Factor Scale

Results

Extent of deforestation

Forest cover significantly declined in Mapfungautsi forest between the period from 2000 and 2020. The use of land use land cover maps was done to determine the extent of deforestation for the 20-year period. Table 3 and Figures 2 to 4 indicate the extent of deforestation which took place in Mapfungautsi forest from year 2000 up to year 2020.

Table 3: Forest cover lost through deforestation in Mupfungautsi (2000 - 2020).

Vegetation cover type	Forest cover in 2000 (Ha)	Deforestation in 2010 (Ha)	Forest cover lost (%)	Deforestation in 2020 (Ha)	Forest cover lost (%)
Wooded land	69295	627	0.9	6780	10
Bushland	5724	1679	29	1781	31
Wooded grassland	2463	1948	79	2071	84
TOTAL	**77482**	**4254**	**5**	**10632**	**14**
Rivers and vleis	5316	-	-	-	-
GRAND TOTALS	**82798**	**4254**	**5**	**10632**	**14**

Table 3 indicates deforestation in hectares and as a percentage for each vegetation cover type (wooded land, bushland and wooded grassland) from year 2000, 2010 and 2020. Total hectares lost to deforestation in Mapfungautsi were after the first decade (2000 – 2010) and two decades (2000 – 2020) were 4254 and 10632 respectively. This translates to 6378 hectares of forest being lost in the second decade (2010 – 2020). This shows that deforestation took place at an accelerated rate from 2010 – 2020.

Forest cover was intact in the year 2000 in Mapfungautsi forest. There was no deforestation detected by the satellite imagery. The total area covered by the forest was 82798 ha and was comprised of forest, rivers and vleis (Table 3). Only southern boundary had a small patch (244 ha) cleared by farmers from Nkayi district.

The extent of deforestation in Mapfungautsi forest in the year 2010 was 4254 hectares (Table 3 and Figure 3). There were four sites where cultivation and settlements took place. Of the four sites, the highest deforestation in terms of hectares occurred in Ngondoma area which measured 1948ha, followed by Zanda which measured 1679ha, Nyamazana at 538ha and lastly Gavave that had 89ha. The forest cover in Mapfungautsi was at 73228ha in 2010, down from 77482ha in 2000.

The extent of deforestation in 2020 was at 10632ha and the areas affected were Zanda village with 1781ha, Ngondoma with 2071ha, Nyamazana with 6678ha and lastly Gavave with 102ha. The total area covered with forest was at 66850ha down from 77482ha and 73228ha in 2000 an 2010 respectively.

Demographics of Respondents

Six age groups emerged from the data collected in key informant

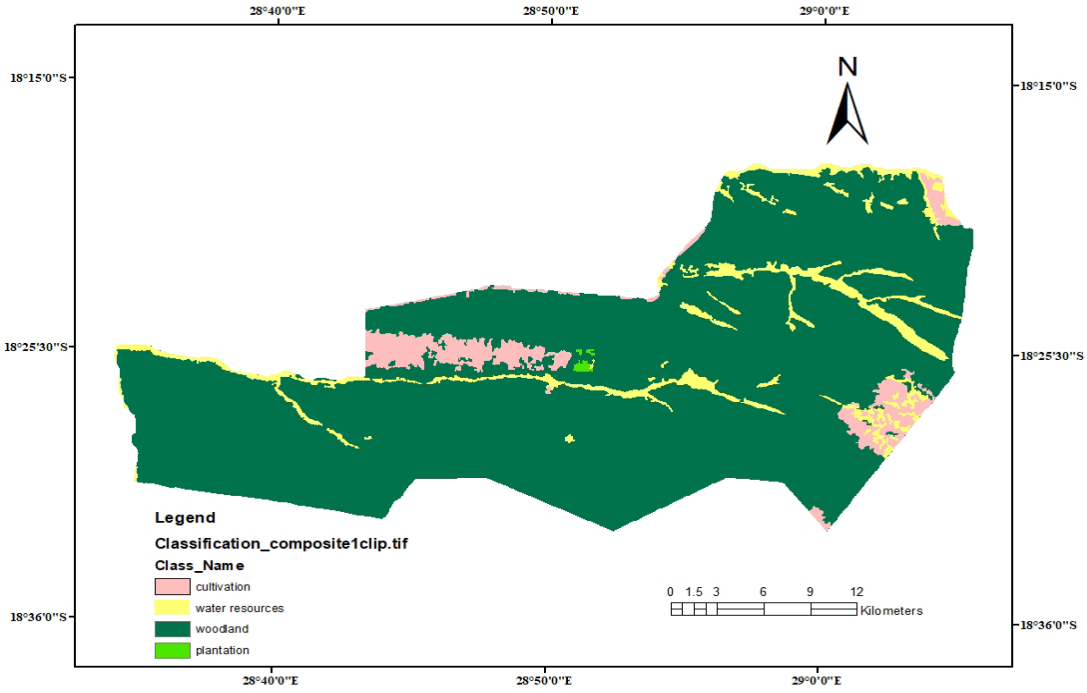

Figure 2: Forest cover map for Mapfungautsi in 2000

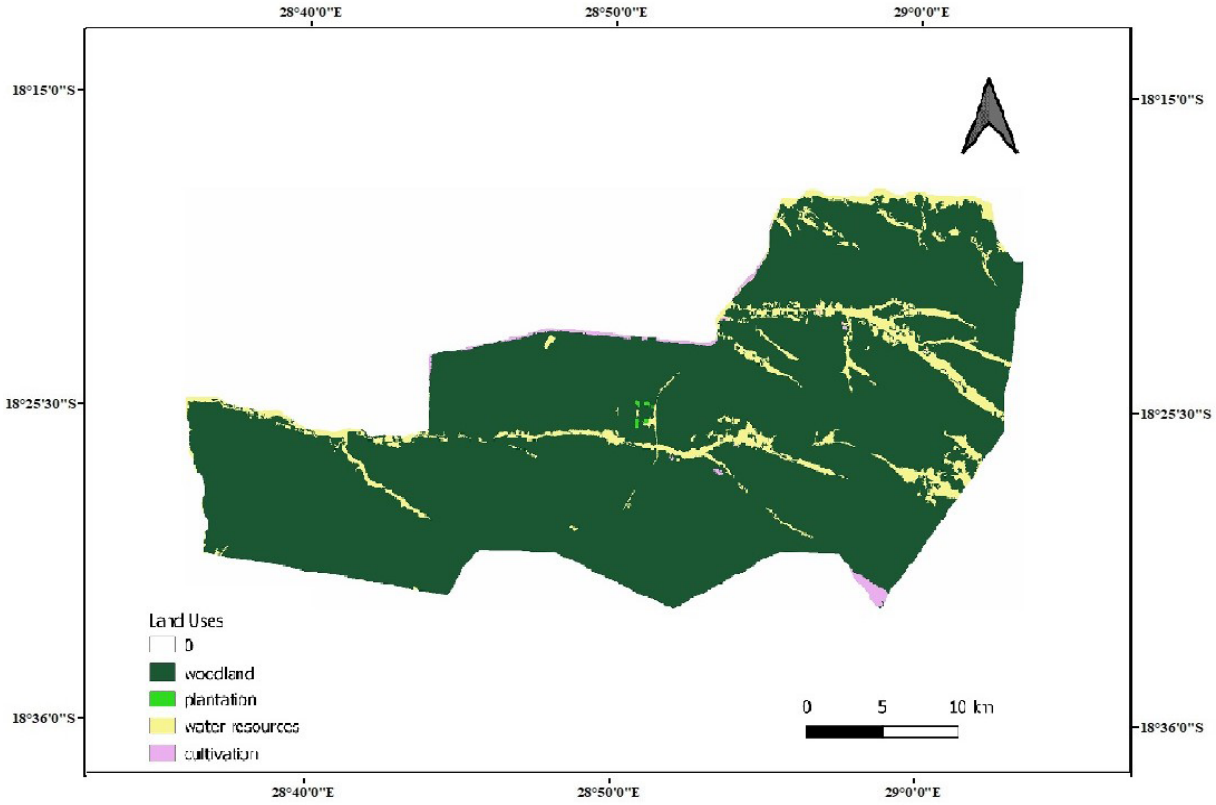

Figure 3: Forest cover map for Mapfungautsi in 2010

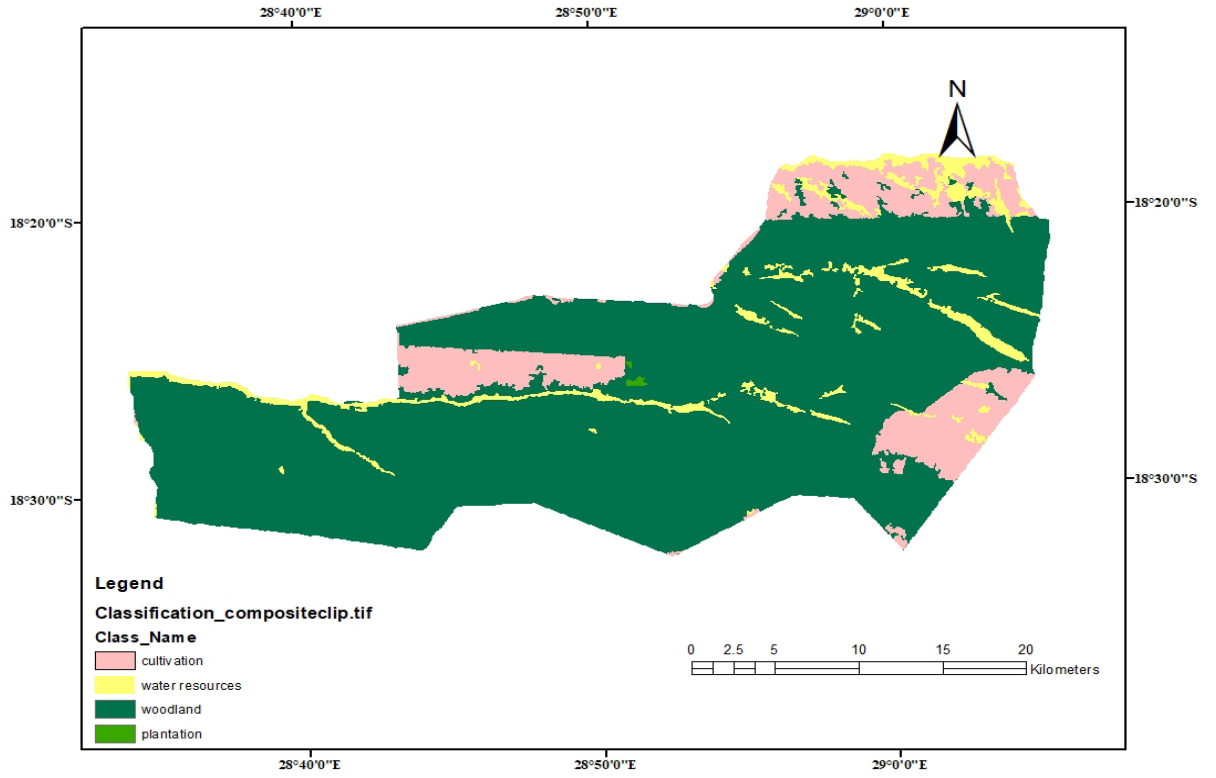

Figure 4: Forest cover map for Mapfungautsi in 2020

interviews and questionnaires (Table 4). The highest percentage of respondents was the age group of 41 - 50 years, followed by the 61 - 70 years and the 51 - 60 years age groups (Table 4). The last two groups were the eldest (71 – 80 years) and youngest (< 30 years) groups respectively. More females participated in the surveys (questionnaires and key informant interviews) than males.

Table 4: Demographics of respondents.

Factor	Category	Frequency	Percentage
Gender	Male	30	46.2
	Female	35	53.8
Age group	< 30 years	6	9.2
	31 – 40 years 41 – 50 years 51 – 60 years 61 - 70 years	8 20 11 13	12.3 30.8 16.9 20
	71 -80 years	7	10.8

Factors Responsible For Deforestation

All the respondents highlighted that they were aware of the forest depletion that has been taking place in the Mapfungautsi forest area. However, what differed among the respondents was the number of years they had observed deforestation taking place as well as their perceptions of the severity of different social and economic factors in causing deforestation. Their perceptions were captured by the factor scales (Table 2) assessed to the various social and economic factors (Figures 5 and 6).

The respondents suggested five social factors namely; population pressure, expansion of chieftainship, unfair share of forest resources with communities, poor access of forest resources and political gain. Amongst these factors, political gain was assessed by respondents to be highly contributing to deforestation, followed by expansion of chieftainship and population pressure, which had the majority of respondents perceiving to be contributing moderately to deforestation (Figure 5).

With regards to economic factors contributing to deforestation, agriculture and firewood poaching for selling were assessed to be the highest contributors by most respondents (Figure 6). Conversely, timber poaching and timber logging were generally assessed to be moderately and marginally contributing to deforestation respectively (Figure 6).

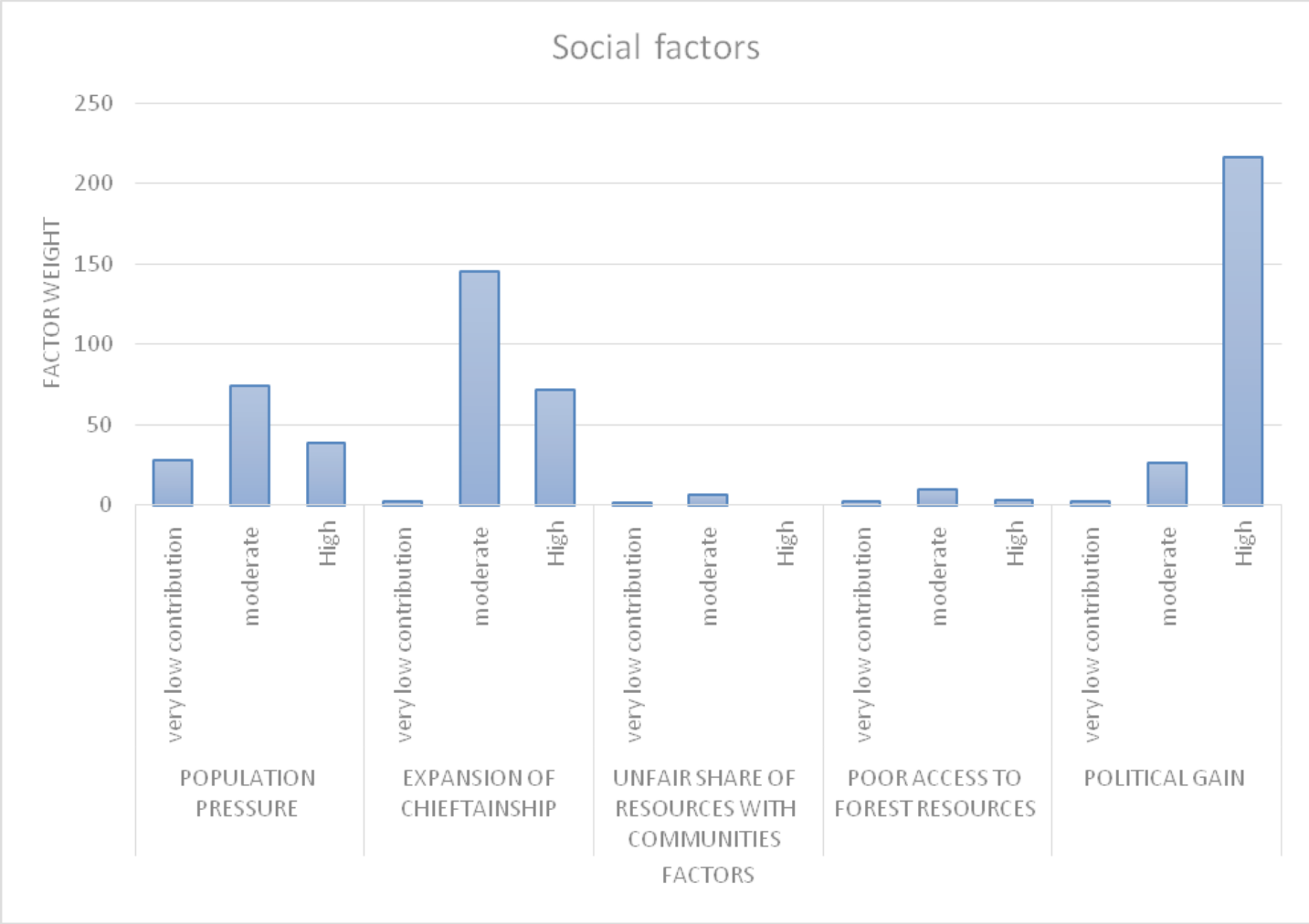

Figure 5: Social factors contributing to deforestation in Mapfungautsi forest

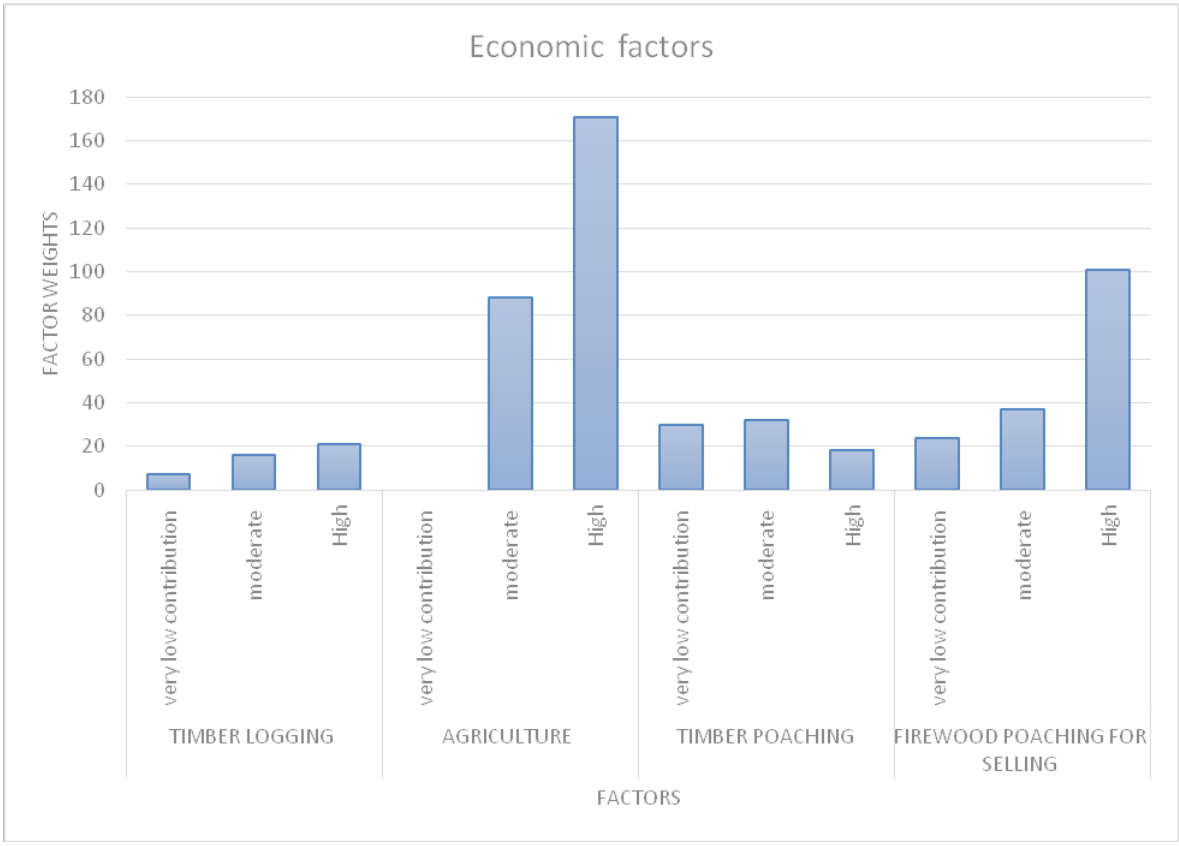

Figure 6: Economic factors contributing to deforestation

Discussion

Extent of deforestation in Mapfungautsi forest

Deforestation in Mapfungautsi forest started after the year 2000. The forest area was 82758 hectares in size but 5% of the forest cover was cleared by the year 2010. Vegetation loss continued in the Mapfungautsi forest between 2010 and 2020 resulting in a significant loss measuring to 14% of the forest area.The areas affected are Zanda, originally a bushland, which up to date has lost 1781 hectares of the forest cover. Sengwa-Mzola area lost 6678 hectares and the original vegetation cover was wooded land dominated by Baikiaea plurijuga and miombo species. The third place affected is Ngondoma, which has lost 2071 hectares up to date. Ngondoma area was originally covered by wooded grassland and some portion of wooded land which were dominated by miombo species. Gababe is the smallest affected area which has lost 102 hectares up to date. The total hectares of forest lost to settlements and cultivation from the year 2000 up to 2020 is around 10632 hectares. A comparison of hectares cleared and vegetation type affected indicate that although wooded land has the biggest size of land that was cleared, wooded grassland was the most affected as indicated by the highest percentage of its area lost.

Bushland was also significantly affected where a third of its area was cleared. Wooded grassland and the bushland were the first to be cleared during the period from 2000 to 2010. Clearing continued from 2010 but targeting wooded land. The pattern and sequence of clearing implies that clearing was primarily done for cultivation because the first targeted areas were wooded grasslands with fertile clay soils favourable for crop production. This was followed by bushland clearing which was generally noted on sloppy areas of the forest where soils are better in terms of fertility and water holding capacity as compared to wooded land.

The clearing which took place from 2010 to 2020 targeted wooded land where soils are generally deep (11 meters deep Aeolian soils) and are not suitable for viable crop production. This implies there could have been a different reason(s) for this forest clearing or that the clearing was a last resort for the settlers. Despite this, the rate at which deforestation increased from 2010 to 2020 was higher as compared to period from 2000 to 2010. The remote sensing imagery results of this rapid decline in land cover were also noted by respondents in both the questionnaires and key informant interviews.

Factors Responsible For Deforestation

There was a good mix of the young and the aged as well as in the gender of respondents. This enabled for the gathering of perceptions on the severity of different social and economic factors in causing for deforestation from people of diverse circumstances. Respondents in the older age groups shared an 'eye witness' account of the changes in the forest cover from the time deforestation started around the year 2000. The younger age groups shared what they have heard and what they have also observed with regards to deforestation. These diverse experiences from respondents are valuable in getting a reliable and accurate picture on the factors responsible for deforestation in Mapfungautsi.

While it is clear that social factors and economic factors work in combination in causing deforestation in Mapfungautsi forest, respondents suggested social factors were the major contributors. Specifically, respondents suggested that political gain and expansion of chieftainship were the most contributing factors to deforestation. Both the local politicians and chiefs were noted to be allocating land to the landless local people as well as migrants from other areas and were often encroaching into the protected forest area for their own personal ambitions. Chiefs did it to increase their areas of jurisdiction while politicians did so for political expediency notably gaining popularity, establishing a wide electorate base and vote buying in time for the two local and national elections were held in 2013 and 2018. Consistent with Chirisa et al. [11], Boone [12] and Scoones et al. [13], land has been used as a tool for political favor and as 'bait' for garnering votes through election promises. It is widely believed that the chiefs always work in cohorts with local ruling party politicians in assisting them to win elections as most chiefs in the country are active activists of the governing party in Zimbabwe. This is a case of distributive politics, which Chirisa et al. [11] described as a situation where political players exercise their control over government or public goods to allocate resources to their loyal supporters on the basis of political patronage.

Beyond these two main social factors, another notable factor was population pressure. Again, this factor is closely related to both political gain and expansion of chieftaincy as it pertains to clearing forests for resettlement purposes. The allocation and clearing of forest is at the behest of either the local chief or local politicians. Population pressure forces families to migrate to areas where there is 'enough space' for agriculture and settlements – real or perceived. Since Zimbabwe's fast track land reform programme in the year 2000, there has been misconceptions by many people, politicians and traditional leaders/chiefs included, on what constitute underutilized land. In their flawed views, many are allocating and or invading protected areas (forests and conservancies) misconstruing them for underutilized land. This has become a driver of deforestation in many protected areas. According to Gotore et al. [2] and Zvobgo and Tsoka [5], the fast track land reform programme was responsible for the accelerated rate of deforestation in Zimbabwe.

While assessed to be marginally contributing to deforestation by most respondents, poor access to resources and unfair share of forest resources may actually be critical in solving the deforestation challenge. For one, disgruntled community members due to what they perceive to be unfair sharing and poor access to forest resources might lead to low stakeholder participation in the management or protection of the forest. This then presents a new set of challenges including lack of motivation in enforcing agreed protection principles and reporting of culprits who poach timber for firewood. Further, as highlighted by some respondents, some de-motivated community members may resort to cutting down trees and starting fires unnecessarily as a form of retaliation for not benefitting from the forest resources.

Economic factors played their part in contributing to the already discussed accelerated rate of deforestation in Mapfungautsi forest during the 2010 - 2020 decade. Consistent with Gotore et al. [2], Tejaswi [3], Zvobgo and Tsoka [5] and Hosonuma et al. [14], the main contributors to deforestation were agriculture, timber poaching, firewood poaching for selling and timber logging. Agriculture was not only the highest contributor to deforestation among economic factors, but was also the overall individual factor assessed to be responsible for deforestation based on the factor weights assigned to it by respondents. Its impact was greater than the two main social factors; political gain and expansion of chieftaincy. It makes perfect sense for agriculture to be the main contributor to deforestation, as both the main social factors, political gain and expansion of jurisdictions of chiefs involved clearing land mainly for settlement and agriculture (which is the main livelihood source for most of the local people). Similarly, Hosonuma et al. [14] found that agriculture accounted for 73% of total deforestation extent in the world. Further, some farmers in Mapfungautsi are practicing shifting cultivation due to the fragility of the soils in some parts of forest leading to massive non-stop clearing of forest for cultivation. This is consistent with Pelletier et al. [4] and Zvobgo and Tsoka [5], who noted that deforestation, is a challenge in regions where fragmented small-scale agricultural production is increasing.

Firewood poaching and selling was seen as a lucrative business by some community members. According to some respondents, some community members were clearing land under the guise of cultivation but their main target would be to supply the felled trees as firewood to nearby urban centres particularly Gokwe, which is 17km away. It is important to note that, some of these community members engaging in the firewood and timber poaching could those disgruntled members of the community who felt they were not getting an equal share and access to forest resources. Again, this shows the interconnectedness of social and economic factors contributing to deforestation.

Conclusions

Analyzing the extent and pattern of deforestation spatio-temporally and the perceptions of respondents on factors responsible for deforestation provided a multidimensional view on deforestation in Mapfungautsi forest. Monitoring of deforestation by remote sensing techniques proved to be effective and accurate as the Landsat images on the deforestation patterns were matched by information collected from members of the community and key informants.

Clearing of land on wooded grassland and bushland was primarily for agriculture since the areas cleared had better soils compared to the rest of the forest area and were the first to be occupied by settlers. Clearing of wooded land with deep Aeolian soils, which are not suitable for crop production, was done for political gain and expansion of the area of jurisdiction by local chiefs to settle migrants from other areas. This action by political and traditional leaders, whom some argue work in cohorts to advance their

own political ambitions is done based on the misconception that protected areas (forests and conservancies) are underutilized land. Consequently, the resettled people depend on agriculture for their livelihoods, yet the most soils in the Mapfungautsi forest are very fragile and cannot support viable intensive crop production year-in year-out. This has led to resettled farmers to practice shifting cultivation within the Mapfungautsi forest leading to continuous massive deforestation.

The foregoing indicates that the single most impactful factor responsible for deforestation in Mapfungautsi forest is agriculture. This is because the two main social factors; political gain and expansion of the jurisdictions of chieftaincies involve authorizing the forest clearing for resettlement and cultivation. Consequently, any control measures to arrest deforestation in Mapfungautsi and any other protected forests for that matter, will require serious buy-in and will power from political and traditional leaders and other stakeholders like farmers and community members.

As Masere and Worth [15] posited, under such a setup involving multiple stakeholders in developing solutions to issues confronting them, genuine engagement is key.

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