



Agricultural Policy Research in Africa



# **THE POLITICAL ECONOMY OF LAND USE AND LAND COVER CHANGE IN MVURWI AREA ZIMBABWE, 1984–2018**

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# ACRONYMS

<b>AGRITEX</b>	Agricultural Technical and Extension Services
<b>APRA</b>	Agriculture Policy Research in Africa
<b>ESAP</b>	Economic Structural Adjustment Programme
<b>FGD</b>	focus group discussion
<b>FTLRP</b>	Fast Track Land Reform Programme
<b>GIS</b>	Geographic Information System
<b>GNU</b>	Government of National Unity
<b>GPA</b>	Global Political Agreement
<b>GPS</b>	Global Positioning System
<b>KII</b>	key informant interview
<b>LULCC</b>	land use and land cover change
<b>LSCF</b>	large-scale commercial farm
<b>MDC</b>	Movement for Democratic Change
<b>NDVI</b>	Normalised Difference Vegetation Index
<b>ODK</b>	Open Data Kit
<b>STERP</b>	Short Term Emergency Recovery Programme
<b>ZANU-PF</b>	Zimbabwe African National Union-Patriotic Front

# EXECUTIVE SUMMARY

An analysis of the variations in land use and land cover over the past four decades in the Mvurwi area, Mazowe district, Zimbabwe illustrates how socio-economic dynamics and natural factors combine to shape environmental change. Land use and cover changes (LULCC) were assessed using a combination of quantitative analysis (satellite imagery) of land cover and a grounded analysis of the social, economic and political factors. Normalised Difference Vegetation Index (NDVI) was calculated on Landsat data to test for significant changes in the vegetation cover at five-year intervals from 1984 to 2018 in the study area. NDVI was used because its simplicity and applicability to vegetation-base studies has been tested extensively and successfully in different categories of remote sensing techniques used to monitor agriculture and plant growth. In addition, Landsat was selected since it is the only satellite mission that covered the whole spectrum of the study period. Statistical analysis of land cover changes was complemented with field-based ground-truthing and interviews with land users. The study revealed four phases of vegetation cover change. The first phase, 1984–1999, showed an increase in vegetation cover, while the second phase, 1999–2004, showed a decrease in vegetation cover. The third phase, 2004–09, showed an increase in the vegetation cover and then the fourth phase, 2009–18, showed a decrease in vegetation cover. To gain a more granular view, a focused study was carried out on one Ward. The study revealed that changes were varied across the area, which included communal areas (small-scale farming), large-scale commercial farms/estates and, after the land reform in 2000, resettlement areas with different farm sizes. Explanations for these changes highlight social, economic and political drivers that have changed over time. A simple, linear explanation of LULCC is inappropriate as multiple drivers intersect, and environmental change must always be understood as co-constituted with social dynamics and political economy.

**Keywords:**

GIS, image classification, land reform, NDVI, Remote sensing

# 1 INTRODUCTION

This study examines LULCC over four decades in Mvurwi area of northern Zimbabwe. The aim was both to examine the extent of change and explore the underlying drivers. The study area allowed for an exploration of land cover changes in former large-scale commercial farms (up to the year 2000), new resettlements areas (after 2000) and a smallholder farming communal area. Taking a multi-decade time-frame, this study explores how land cover varies through different phases, with periods of vegetation expansion and contraction linked to a range of factors. A simplistic, linear explanation of environmental change is thus avoided, and a more nuanced picture emerges, which situates land use change in longer term socio-ecological and political economy dynamics.

Past studies have offered important qualitative insights into LULCC in Zimbabwe, particularly around the post-2000 land reform programme (Murisá 2016; Cliffe et al. 2011; Chigumira 2010), as well as more quantitative assessments of particular areas (Solomon et al. 2018; Matavire, Sibanda and Dube 2015; Mutanga, Ramoelo and Gonah 2013; Matsa and Muringaniza 2011). Few studies have combined a quantitative analysis of land cover, using satellite imagery, with a grounded analysis of the social, economic and political factors that influence change. Too often the result is a simplistic interpretation of satellite image analysis – the ‘gaze from space’ – making assumptions about environmental changes informed by dominant narratives, and without a detailed analysis of what happened in particular places informed by local accounts (Scoones 2018; Jombo et al. 2017).

The application of remote sensing techniques using satellite imagery has become an important tool for the management, mapping and monitoring of landscape changes over time and at various scales (Attri, Chaudhry and Sharma 2015). At global scale, Myneni et al. (1997) calculated the increase in plant growth over the northern latitudes. Sibanda and Murwira (2012) distinguished cotton from maize and sorghum fields in smallholder agricultural landscapes of Southern Africa. Other studies (e.g. Sun et al. 2019; Levin 2015; Rawat and Kumar 2015) have been conducted at national and district levels.

Remote sensing provides an effective and economic means to collect data to monitor changes occurring in land use categories (Sharma et al. 2019). Satellite remote sensing is an ideal source for mapping LULCC, given its ability to provide consistent and repeatable measurements at a spatial scale appropriate for capturing both natural and human-induced phenomena (e.g. fires, disease, agriculture, urbanisation, deforestation) (Gómez, White and Wulder 2016). Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other; while land use describes the use to which the land is put, and there may be different uses for lands with the same cover type (Coffey 2013).

There has been rapid development of remote sensing data of several multi-spectral, multi-temporal and multi-spatial ranges.<sup>1</sup> In this study we use imagery from the Landsat satellites because of their uniqueness in the application of land cover classification through continuous observation history since its launch in 1972 (Wulder et al. 2016). Landsat is the longest running uninterrupted Earth observation programme and its archives are the first to offer global images free of charge and provide insights into past trends that are important when monitoring land cover changes (Turner et al. 2015). In addition, Landsat satellites’ resolution characteristics (temporal, spatial and spectral) and other technical specifications make them suitable for LULCC detection for larger areas (Mensah, Wapaburda and Hammond 2017).

Timely and accurate change detection of the earth’s surface features provides the basis for evaluating the relationships and interactions between human and natural phenomena (Asokan and Anitha 2019). Digital image processing of satellite data provides tools for analysing the image through different algorithms and mathematical indices. Features are based on reflectance characteristics, and indices have been devised to highlight the features of interest on the image (Gao 1996). There are several indices for highlighting vegetation-bearing areas on a remote sensing scene. Vegetation indices, among other methods, have been reliable in monitoring vegetation change (Nageswara et al. 2005).

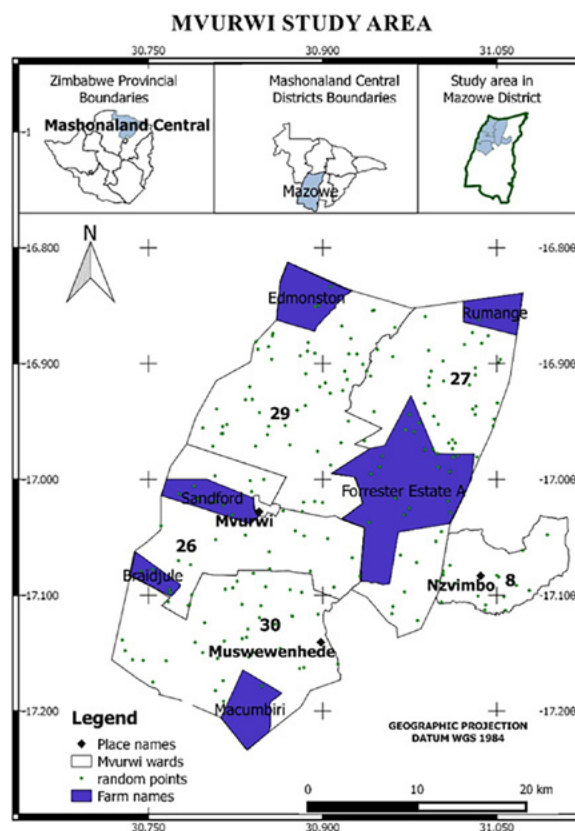
One of the most widely used indices for vegetation monitoring is the NDVI (Tucker 1979), which is widely applied in research on global environmental and climatic change (Gao 1996). According to Rouse *et al.* (1974) NDVI is calculated as follows:  $NDVI = (NIR + R) / (NIR - R)$  whereby NIR and R is the surface reflectance in the near-infrared and red bands respectively. NDVI values range from -1 to +1. Dense vegetation is represented by high NDVI values, between 0.1 and 1. Conversely, non-vegetated surfaces such as water bodies yield negative values of NDVI because of the electromagnetic absorption quality of water. Bare soil areas represent NDVI values that are closest to 0 due to high reflectance in both the visible and NIR portions of the electromagnetic spectrum (Lillesand and Keifer 1994).

## 2 STUDY AREA

The study was carried out in Mvurwi area of Mazowe District, which is located in Mashonaland Central Province of Zimbabwe, around 100km from the capital Harare, as shown in Figure 2.1. The area has been the focus of a longitudinal study of changes in commercial agriculture (Scoones *et al.* 2020), and this provided an important source of information to complement the satellite-based land cover analysis. Five Wards that were formerly large-scale commercial farms (now A1 and A2 resettlement areas) and one Ward that is within Chiweshe communal area (Ward 8) were selected randomly for the study. The mean elevation of the study area is 1,350m above sea level. The area has savannah type of grassland as well as *miombo* woodland. Dominant soil types are haptic luvisols,

ferralic cambisols and chromic cambisols. The main economic activity in the study area is agriculture, with farmers mainly growing tobacco and maize.

**Figure 2.1: Location of study area and sample points.**



Source: Authors' own



# 3 METHODS

Our focused study was conducted in Ward 26, which was formerly a large-scale commercial farm area, and since 2000 has been converted to a mix of smallholder and medium-scale farm resettlements with 68 per cent model A1 farms (small-scale) and 32 per cent model A2 farms (medium-scale). Ward 26 was chosen for the granular study because of its proximity to Mvurwi town and its strong interaction between farming and urban areas economically, socially and environmentally through the interlinked spaces. The study quantified LULCC using a combination of NDVI analysis and a supervised classification method for the four phases under study, during the period 1984–2018.

In addition to the NDVI analysis and image classification in Ward 26, four FGDs and eight KIIs were held in Wards 8 and 26, as a means to help explain the NDVI analysis from a local perspective. Questions were asked on the economic activities of the area prior to resettlement, and how these have changed over time covering the study period (1984–2018). The influence of politics on the pace and intensity of development on land during the study period was also analysed. Selection of FGD and KII participants was based on position in government departments, age and length of stay on the farms. Field data were collected using Open Data Kit (ODK) suite, a Computer Aided Personalised Interviewer (Brunette *et al.* 2013). The questionnaire was digital and administered using android phones.

The questionnaire collected information such as GPS location, current LULCC, the previous LULCC, year when LULCC changed from the current, image of the area, other changes in LULCC and years and reason for each LULCC.<sup>i</sup>

In this study, satellite data from Landsat satellites was used to extract proxies for measuring vegetation condition over the years 1984–2018. Landsat satellites’ resolution characteristics (temporal, spatial and spectral) and other technical specifications make them suitable for LULCC detection for larger areas (Mensah, Wapaburda and Hammond 2017). The first Landsat was launched in 1972, however imagery between 1972 and 1984 was not used in this study because this period did not have imagery corresponding to our study period (May–June) as well as the five-year intervals. May to June is the time when the grass has dried out and much of the reflectance that affects NDVI is due to trees. The same period was used because vegetation cover varies with time of the year, hence using the same period would account for the LULCC without bias (Matavire, Sibanda and Dube 2015).

The years that were used for the study are 1984, 1989, 1994, 1999, 2004, 2009, 2014 and 2018. A shape file demarcating the study area was obtained from the Surveyor General Department in Zimbabwe. All imagery used has a cloud cover of less than 5 per cent.

**Table 3.1: Landsat sensors and bands used for calculating NDVI (1984-2018)**

Date acquired	Spacecraft	Sensor	Spatial resolution	Bands (4)	
				NIR	Red
22 June 1984	Landsat 5	MultiSpectral Scanner	60m	3	2
02 June 1989	Landsat 5	Thematic Mapper	30m	4	3
18 June 1994	Landsat 5	Thematic Mapper	30m	4	3
15 May 1999	Landsat 5	Thematic Mapper	30m	4	3
28 May 2004	Landsat 5	Thematic Mapper	30m	4	3
26 May 2009	Landsat 5	Thematic Mapper Operational Land	30m	4	3
28 May 2014	Landsat 8	Imager Operational land	30m	5	4
04 June 2018	Landsat 8	Imager	30m	5	4

Source: Authors’ calculations from USGS 2018 data.

Landsat 5 (Thematic Mapper), Landsat 8 (Operational Land Imager), both with a spatial resolution of 30m, and Landsat 5 (Multi Spectral Scanner) with a spatial resolution of 60m were used in this study, as shown in Table 3.1. Table 3.1 also shows the bands used to calculate NDVI. The satellite image tiles that were downloaded from earth explorer website (<https://earthexplorer.usgs.gov/>) are of World Reference System path 170 and row 72.

In this study, 200 random sample points were generated from the study area. These points were used for NDVI and rainfall data extraction. Random sampling was used, as the study area belongs to one agro-ecological region. Rainfall data was extracted at the same sampled points used for NDVI for each study year. Mean rainfall values were compared with those of NDVI to test if there was a relationship. The satellite imagery was corrected for radiometric, geometric and atmospheric errors before being used. It then went through the process of spectral and spatial subsetting (Mensah, Wapaburda and Hammond 2017). Satellite imagery comes with a lot of spectral bands. Therefore, spectral subsetting was performed so that few spectral bands to be used are selected. Spatial subsetting was also performed and unwanted geographical areas were removed to remain within the study area.

NDVI and land cover maps were produced to visualise the trend in vegetation cover between 1984 and 2018. The maps were used for exploratory data analysis prior to statistical tests. NDVI values were extracted at the 200 randomly sampled points in a Geographic Information System (GIS) environment. Cumulative rainfall data was downloaded from CHIRPS website (CHIRPS 2019) and extracted at sampled points for each study year (1984–2018).

Normality tests for the NDVI values at sampled points were conducted using the quantile-quantile (Q-Q) plots, a statistical test which tests whether the data is normally distributed or not (Atsalakis, Bouri and Pasiouras 2020; Zubir *et al.* 2018). If the data follow a normal distribution, the points in the Q-Q normal plot lie on a straight diagonal line. Following the normal

distribution of the data ( $p>0.05$ ), the paired sample t-test was used to test whether there were any significant differences between vegetation NDVI signals amongst different years. The test was conducted at a 95 per cent confidence interval. According to Jennings, Zumbo and Joula (2002), it is still possible to use the paired samples t-test, provided that the sample size is at least 30; in this study, 200 samples were used. Furthermore, Spearman's Rho, a non-parametric correlation test, was calculated to measure the strength of the relationship between rainfall and NDVI over the four phases (1984–99, 1999–2004, 2004–09 and 2009–18). Image classification was performed in Ward 26 where the study was more detailed. The data for the process was collected in the field using ODK and uploaded to the server. It was then downloaded from the server and divided into training (70 per cent) and testing (30 per cent). Training data was used on the processed imagery during the classification process. Testing data was used as ground-truth data in the accuracy assessment process. The major land classes observed in the field were bare ground, fields, forests, water bodies and grasslands, as shown in Table 3.2. Each pixel was classified according to the land class that covers more than half of the area (Islam *et al.* 2018).

Since there is no single classification method that works best on all remote sensing images, because images have varying spectral, temporal and spatial characteristics, several hard classification methods (Kamavisdar, Saluja and Agrawal 2013) were performed. This enabled the selection of the best method in terms of the overall accuracy and robustness for the final classification (King *et al.* 2001; as cited by Johnson *et al.* 2013). June 2018 imagery was used for the classification, so as to select the best algorithm, and then used to classify imagery for the remaining years in Ward 26.

Methods used were: (1) Maximum likelihood, based on the Bayes Theorem (Maselli and Conese 1994); (2) Minimum distance to mean approach, which calculates mean spectra of each predefined class and assigns the pixel to a group that has the least distance to the mean (Abburu and Suresh 2015); (3)

**Table 3.2: Land cover classes**

Class	Description
Bare ground	Includes areas with no or sparse vegetation. Roads are included.
Fields	Includes harvested or not harvested fields.
Forests	Includes areas with forest vegetation cover.
Water bodies	Includes all water bodies such as dams, lakes and rivers.
Grassland	Includes areas where grass is the dominant vegetation type.

Source: Authors' own

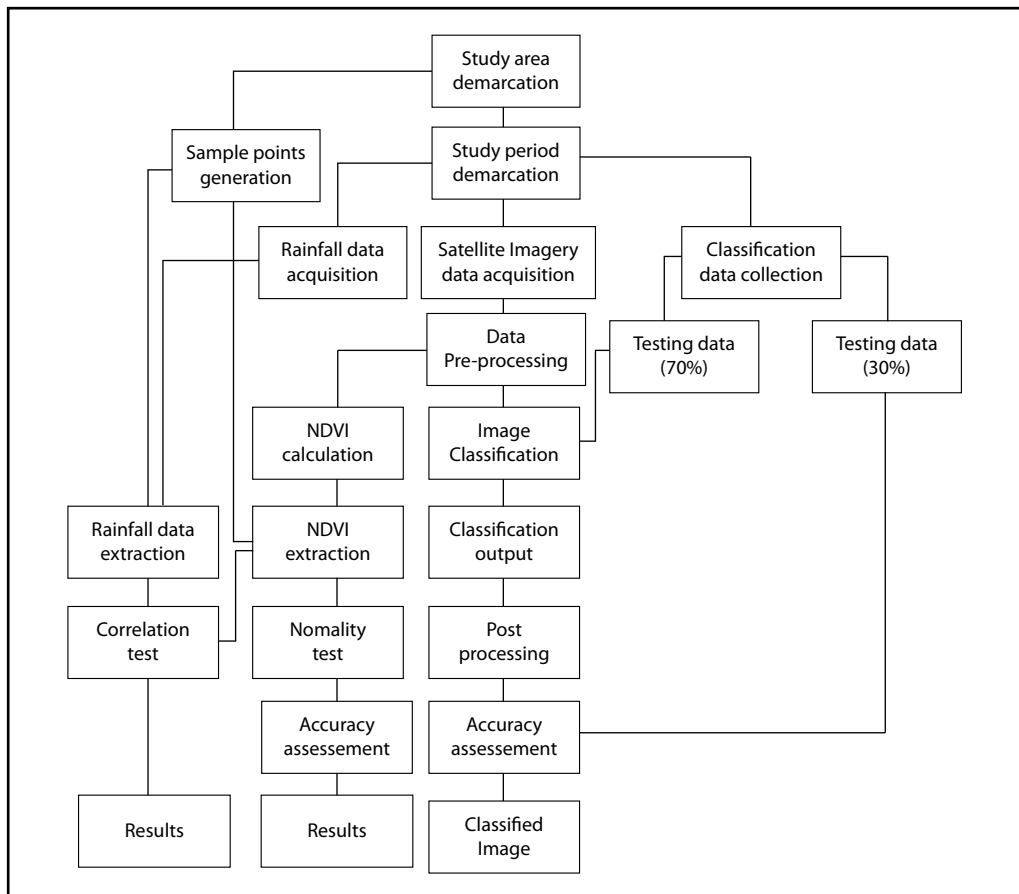
Spectral angle mapper, which is a physically-based spectral classification that uses an n-dimensional angle to match pixels to reference spectra (Zulhaidi, Suhaili and Mansor 2007) and (4) Mahalanobis distance classifier, which is based on a correlation between variables by which different patterns can be identified and analysed (Marghany and Hashim 2011).

Post-classification processing was conducted on each classification method. This was done in order to assess if there are classes that are nearly the same and whether there is need to combine them. Field and bare classes were merged to the fields class due to their reflectance characteristics. This is justified, as at the time of image acquisition (4 June 2018; see Table 3.1), some fields were already harvested, and therefore were classified as bare (Matavire, Sibanda and Dube 2015). Accuracy assessment was done for each classification method using Kappa statistics index (Haque and Basak 2017; Mensah, Wapaburda and Hammond 2017) which indicates the extent of agreement between the observed and expected results. Accuracy assessment is a validation process that is conducted by comparing the classification results with ground-truthed referenced data (Brabyn *et al.* 2013). Overall

accuracy quantifies how well a classification was done by the classifier (Mensah, Wapaburda and Hammond 2017) by showing the proportion that was correctly mapped out in the given reference sites. The higher the value, the better the classification method. Following these assessments, the maximum likelihood method produced the best classification results and was therefore used for classifying the imagery in Ward 26.

Figure 3.1 shows a summary of the steps taken in this study. The study area was identified and demarcated; Landsat satellite data was acquired and pre-processed; random sample points were selected from the study area; NDVI was calculated using satellite imagery of the sampled points; the results were tested for normality and, finally, tests for significant changes over the years were performed. Ground-truthing was conducted, together with interviews on changes in NDVI and land cover in Wards 8 and 26.

**Figure 3.1: Methodological approach for the satellite imagery element of the study**



Source: Author's calculation

# 4 STUDY RESULTS: CHANGING LAND COVER IN MVURWI

Figure 4.1 shows NDVI maps from exploratory data analysis. A general pattern is observed, with four phases (1984–99, 1999–2004, 2004–09 and 2009–18). Across the whole area, there is an increase in NDVI during the first phase, from 1984–99 (more vegetation cover) to a peak NDVI of 0.32 (Figure 4.2) in 1999. This period coincides with the Economic Structural Adjustment Programme (ESAP) implemented by the Government of Zimbabwe between 1990 and 1995.

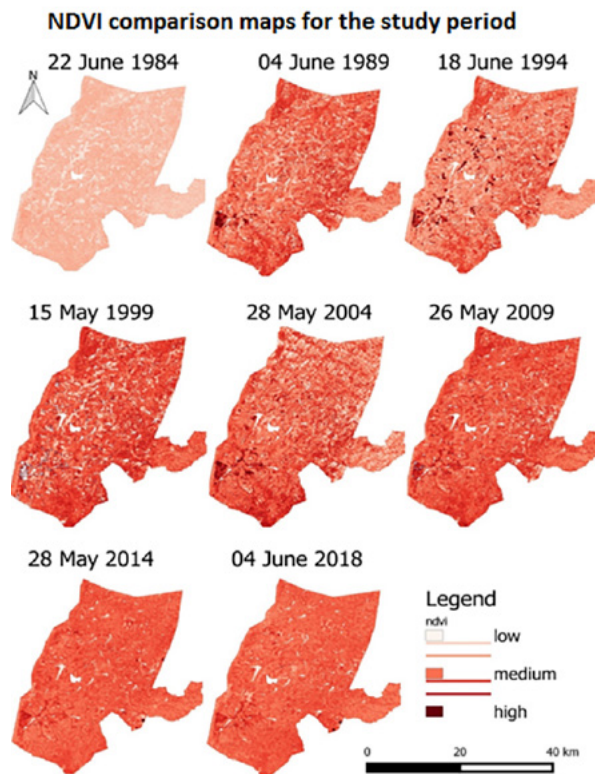
Figure 4.2 shows that before ESAP (1984–1989) the rate of increase in NDVI is less than during the ESAP period (1990–95) and post-ESAP under the Zimbabwe Programme for Economic and Social Transformation (ZIMPREST, 1996–99), which has more vegetation cover. From 1999 to 2004 (the second phase), there is a decline, with NDVI at 0.27 by 2004. From 2004–09 (the third phase) there is another increase to NDVI at

0.30, followed by a sharp decline to an NDVI of 0.23 in 2014, after which the rate of decline decreases to a value of 0.22 in 2018. With some important variations (notably Ward 30, see Figure 4.2), the overall pattern of four phases was shown in each Ward, with a fluctuation of NDVI values seen over time. Furthermore, Figure 4.2 shows that there is weak correlation between NDVI and rainfall during the first phase (1984–99) whilst there is a strong correlation during the second (1999–2004), third (2004–09) and fourth phases (2009–18).

## Normality tests results

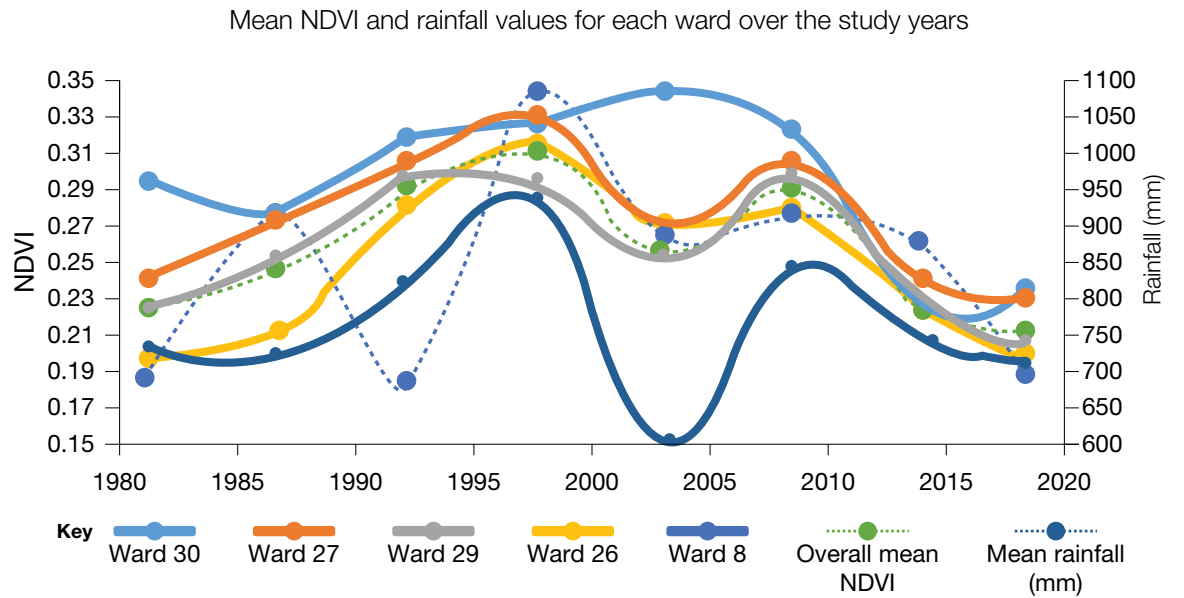
The Q-Q Plots in Figure 4.3 illustrate that NDVI data for the study years was normally distributed, hence parametric tests for significant difference were conducted.

**Figure 4.1: Comparison of NDVI between the study years**



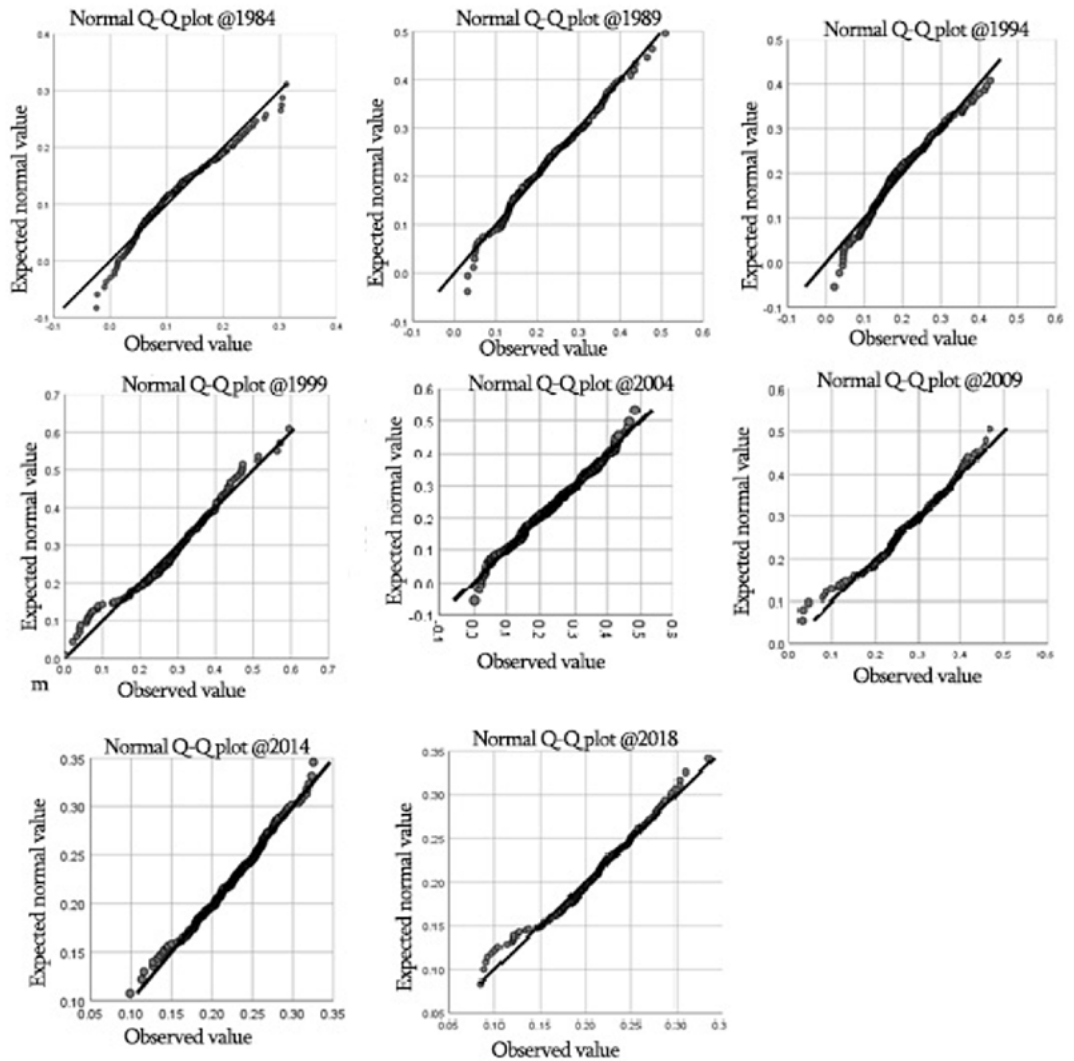
Source: Authors' calculations from USGS, 2018 data

Figure 4.2: Average NDVI values for each ward and mean rainfall from 1984 to 2018



Source: APRA study using USGS, 2018 data

Figure 4.3: Q-Q Plots for normality test



Source: Authors' own

#### 4.1 Paired sample t-test results

Paired sample t-test results shown in Table 4.1 illustrate that there were significant changes ( $p < 0.05$ ) in NDVI values between each image date. There were significant increases of NDVI (more vegetation cover) in the first (1984–99) and third phase (2004–09), whilst there were significant decreases in NDVI (less vegetation cover) in the second (1999–2004) and fourth phase (2009–18) (Figure 4.2).

#### 4.2 Spearman's Rho correlation test results

Spearman's Rho correlation test results, as indicated in Table 4.2, show that there is weak correlation ( $r = 0.4$ ) between NDVI and rainfall during the first phase (1984–99) whilst there is a strong correlation during the second phase (1999–2004), third phase (2004–09) and fourth phase (2009–18).

#### 4.3 Classification results

In order to understand these patterns of NDVI change in relation to different land cover types, we looked in detail at changes in Ward 26, and chose the best classification method. Table 4.3 shows that maximum likelihood method gives the best accuracy of 93.08 per cent and a Kappa coefficient of 0.8816, and was therefore used for classifying the satellite imagery.

Figure 4.4 and Figure 4.5 indicate that grassland occupies much of the study area throughout the study period, occupying not less than 9,500ha from 1984–2018 and reaching a peak of 13,500ha in 2004. Figure 4.4 also shows that forest cover occupied 5,000ha in 1984, going down to 2,000ha by 2004, and rising slightly to about 2,400ha by 2010.

**Table 4.1: Paired sample t-test results showing significant differences in NDVI**

Paired samples test at 90% confidence interval			
Study years	df (total sample size minus 1)	sig. (2-tailed)	Sig. (2-tailed) (2 decimal places)
1984 - 1989	199	8.30419E -51	0.00
1989 - 1994	199	3.4 48963E -05	0.00
1994 - 1999	199	1.26839E -17	0.00
1999 - 2004	199	3.86926E -08	0.00
2004 - 2009	199	3.48815E -09	0.00
2009 - 2014	199	4.92555E -24	0.00
2014 - 2018	199	2.78817E -06	0.00
1984 - 2018	199	3.18464E -53	0.00

Source: Authors' own

**Table 4.2: Spearman's Rho correlation test results of the four phases**

Phase	Spearman's Rho
1 (1984–99)	.400
2 (1999–2004)	1*
3 (2004–09)	1*
4 (2009–18)	1*

\*Correlation is significant at the 0.01 level (2-tailed).

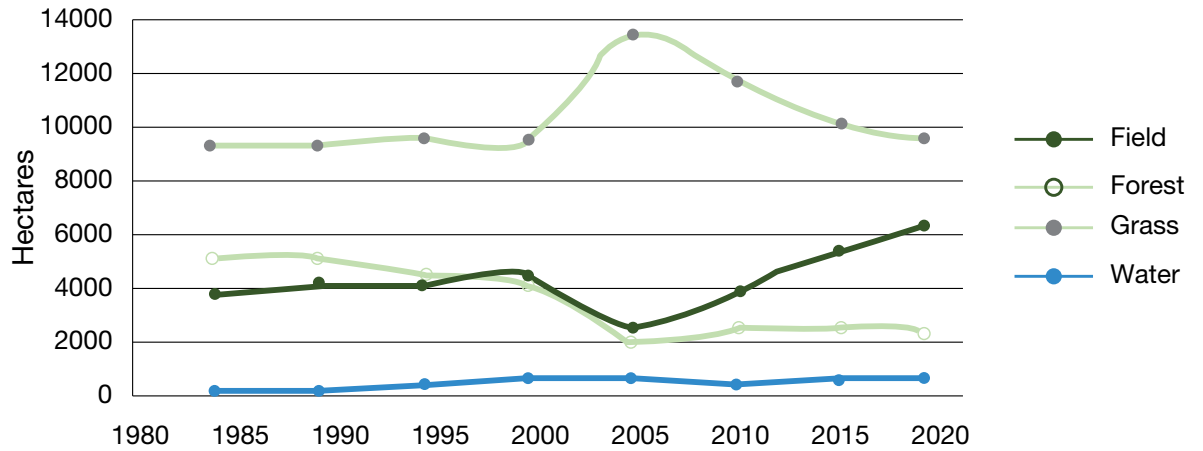
Source: Authors' own

**Table 4.3: Accuracy results for the classification methods**

Classification method	Overall accuracy (%)	Kappa coefficient
Maximum likelihood	93.08	0.8816
Minimum distance to mean	69.74	0.5651
Spectral angle mapper	68.72	0.5409
Mahalanobis	70.77	0.5824

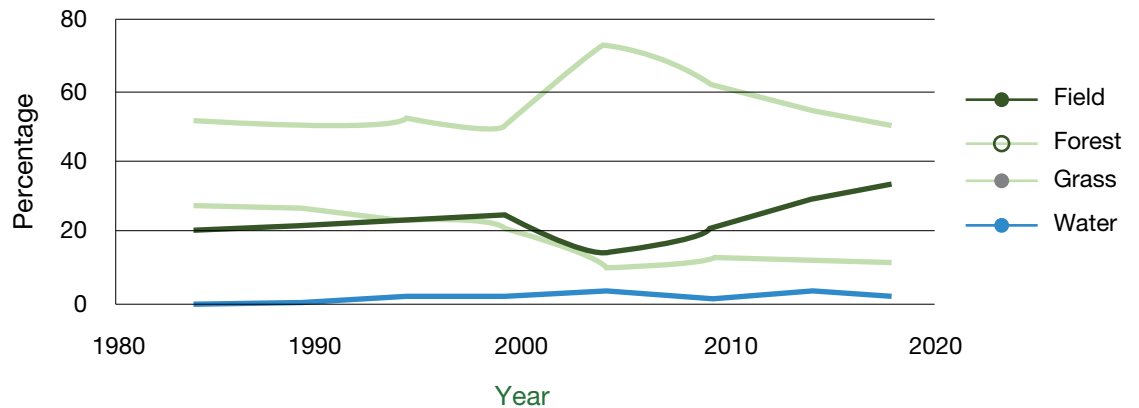
Source: Authors' own

Figure 4.4: Smoothed graph showing land classes in hectares over the study years in Ward 26



Source: Authors' own

Figure 4.5: Percentages of area occupied by each land class in Ward 26



Source: Authors' own

Not surprisingly, the changes seen in aggregate are linked to conversion of forests to grasslands and fields and *vice versa*. Overall forest cover has declined, although there is a slight increase from 2004–09, before stabilising thereafter. Grasslands increased significantly after 1999 and then decreased after 2004. Areas classified as fields in Ward 26 occupied 3,795ha in 1984 and stabilised around 4,300ha in 1989, until around 1999, at which point they dipped to a low of 2,500ha in 2004, but increased significantly since 2004 to 6,154ha in 2018. Figure 4.4 further shows that area under forest was more than area under fields until about 1999, but since then the overall area has been dominated by cultivated or grassland areas. Areas occupied by water has marginally increased from about 89ha in 1984 to just above 500ha in 2018, presumably due to the construction of Musengezi dam (236ha) in Ward 26, as shown on the satellite imagery of 18 June

1994, and influence of other water bodies (302ha) that start showing on the satellite imagery after 1999.

# 5 EXPLAINING LAND COVER CHANGES, 1984–2018

The previous section has presented the results of the NDVI/land cover analyses both for the area as a whole and for the sample Ward. A general pattern is observed, with four phases. The first phase (1984–99) recorded an increase in forest cover. The second phase (1999–2004) recorded a decline in forest cover due to land clearance after the land reform of 2000. There was an increase in forest cover in the third phase (2004–09) due to the indirect effect of hyperinflation. The fourth and last phase (2009–18) with a variation from 2014 showed a decline in forest cover. While there is a clear shift to more cultivated area/grassland over time, there are important variations; for example, in the late 1990s and between 2004 and 2009 there were increases in denser vegetation. What explains these changes in overall vegetation cover across the area, and the particular land cover changes in Ward 26?

One explanation might simply be rainfall. Studies in Zimbabwe (UNDP 2017) successfully classified rainfall seasons from 1981 to present into different El Niño Southern Oscillation (ENSO) classes. El Niño years often coincide with drought conditions in Zimbabwe (1982–1983; 1997–1998; 2015–2016). 2015/16, a very strong El Niño year, led to a drought in Zimbabwe and the rest of Southern Africa, whilst La Niña years coincide with wet conditions (1998–1999; 1999–2000; 2007–2008; 2010–2011) (UNDP 2017). For the period 1980–2016, El Niño years have been characterised by lower yields compared to non-El Niño nor La Niña years, and La Niña years at national level (UNDP 2017).

However, as Figure 4.2 and Table 4.2 show, there is no significant correlation between land cover/NDVI and rainfall. In some periods, a decrease in both NDVI and rainfall (1999–2004 and 2009–2018) is recorded, but from 1994 to 1999, rainfall rose steeply and NDVI rose gently. However, between 2009 and 2014, rainfall decreased gently even though NDVI decreased sharply. Clearly, the explanation is more complex and, therefore, rainfall level may not be the only variable influencing rainfall-vegetation spatio-temporal relationship. Similarly, Chen, Wang and Fu (2020) concluded that it is reasonable to consider that vegetation response to rainfall anomalies can be influenced by some other factors, for example climatic

and biogeographical factors. More so, others have observed (e.g. Kochy 2008; Camberlin *et al.* 2007; Wang, Rich and Price 2003; Li, Tao and Dawson 2002) that, for tree-dominated ecological zones, NDVI anomalies exhibit weak correlations with rainfall anomalies, because trees with well-developed root systems are able to reach deep soil water resources and are weakly influenced by soil moisture variations. A similar study in Chipinge district of Zimbabwe by Jombo (2016) showed that from 1992 to 2014, rainfall did not have an impact on LULCC. So, if rainfall does not fully explain the changes in land cover, what does? The next sub-sections explore possible drivers.

## Phase 1: 1984–99

Focusing on the first period within this phase (1984–1989), we see an increase in vegetation cover in what were the large-scale commercial farms (LSCFs) (Wards 26, 27, 29). This potentially indicates recovery of vegetation cover from the severe drought of 1982 to 1984 (Kinsey *et al.* 1998); however, there were other major droughts in this period (including 1986–1987) where a similar pattern is not observed. As discussed earlier, rainfall patterns do not appear to be a major determining factor.

Forest cover increases in this period may, however, be a response to the impact of sectoral and macroeconomic policies on the agricultural sector in Zimbabwe. Specifically, the impact of the relatively high cost of doing business in a highly regulated business environment involving price controls, labour market restrictions and trade and investment restrictions during this period. Across the country, this led to a general crop decline in the large-scale commercial sector (Jansen and Rukovo 1992). Following Independence in 1980, and despite the pronouncement of the national reconciliation policy, large-scale commercial agriculture experienced a decline in production in the early Independence years due to multiple uncertainties (Shonhe 2018; Weiner 1988).

The pattern in the core LSCF Wards, however, contrasts with Ward 8 (communal) and Ward 30 (also LSCF) during this period. In these LSCF Wards, there was a decrease in forest cover. After Independence,



the coming of peace and the abandonment of the Protected Villages in Chiweshe, people in the communal areas were able to re-establish extensive fields<sup>iii</sup> (see also, Scoones *et al.* 2020). The contraction of large-scale commercial farming likely resulted in the shedding of farm labour, so former labourers then had to seek livelihoods through farming, which resulted in the clearing of new fields in the communal areas. The post-Independence support for communal area farming also provided incentives to increase production and clear land. After Independence, the Agriculture Finance Company extended support to communal farmers through amendment of the Agricultural Finance Act, which was combined with a massive expansion of agricultural extension, and a range of donor-led projects (Shonhe 2018; Pandey and Ramnarayan 1994).

During the second period in this phase (from 1989 to 1999) there is, by contrast, an increase in NDVI across the whole study area – in all the large-scale commercial farming Wards (26, 27, 29, 30), as well as in the communal area Ward 8. This can be related to a major change in macro-economic policy. Following pressure from the International Monetary Fund and the World Bank, the Government of Zimbabwe implemented ESAP in 1991 (Kawewe and Dibie 2000). ESAP focused on liberalising internal and external trade, by elimination of price controls, reduction of state marketing activities and restructuring of the banking and financial system (Matanda and Jeché 1998). In Zimbabwe, the initial years of ESAP implementation also overlapped with a major drought in 1991–92 (Marquette 1997; Scoones *et al.* 1996). The commercial farmers in Wards 26, 27, 28 and 30 benefited from ESAP through the boosting of export opportunities and the liberalisation of markets. Many commercial farmers in Mvurwi reduced the area under operation and concentrated on more high-value production for export resulting in large land areas under forest, hence the high NDVI (Wadzanayi Saburi, KII, 26 February 2020; Moyo 2000).

The high interest rates, removal of subsidies on agricultural inputs and reduction in government spending during ESAP period, however, had a negative impact on production in the communal and small-scale farming areas, since they relied on government subsidies for farm inputs (Rippenburg 1996). The cost of inputs became unaffordable to many communal farmers. Specifically, the price of fertilisers went up by 300 per cent in the period 1990 to 1995, leading to reduction in acreage under cultivation (Ismi 2004), consequently, a growth of forest area leading to increasing NDVI values was observed in Ward 8 of Chiweshe communal area.

The increase in forest cover – as signified by the increase in NDVI during the first phase (1984–99) and specifically between 1994 and 1999 in the LSCF Wards (26, 27, 30, and up to 1996 in Ward 29) – may be due to a reduction in the area under controlled commodities like maize and the intensification of horticultural activities in the commercial farming areas. The horticulture sub-sector's export market channel grew from US\$3.6 million in 1986 to reach US\$142.7 million in 1999, accounting for 4.5 per cent of the Gross Domestic Product, as Zimbabwe's horticultural exports attained the ranking as one of the leading exporters of the African, Caribbean and Pacific countries (SNV 2014). However, the observed decrease in NDVI from 1996 to 1999 in Ward 29 was likely a result of the expansion of cropped area by commercial farmers who sought to demonstrate their productivity in order to avoid eviction, as tension on the land question increased.<sup>iv</sup> This was during a period of increasing interest in state expropriation of land, accompanied by widespread land occupations (Mkodzongi and Lawrence 2019).

The post-ESAP period of 1994 to 1999 was characterised by many policy reversals, as the government implemented ZIMPREST. While the main objective of ZIMPREST was to correct the mistakes of ESAP, which failed to achieve its results (Bonga 2014), not much was achieved through this new programme either. For instance, many factors between 1994 to 1999 led to a decline in agricultural performance: (1) poor rainfall during the 1997-98 season; (2) a sharp depreciation of the Zimbabwe dollar in 1998, which was due to low prices of Zimbabwe's major minerals on the international market and low international prices of tobacco reducing foreign exchange earnings; (3) the slowdown in global economic performance in 1998, which reduced demand for exports; and (4) an unstable macro-economic environment, characterised by increasing inflation rates, high interest rates and a weak currency that negatively affected performance in most sectors of the economy, particularly manufacturing (Bonga 2014).

The deterioration in the macro-economic environment was also linked to the country's participation in the Democratic Republic of Congo war and the large payout to war veterans, which led to Black Friday of 14 November 1997 (Shonhe 2018). Economic challenges were therefore linked to a decline in cropping area, signified by the increase in NDVI as shown in the satellite images of 18 June 1994 and 15 May 1999.

## Phase 2: 1999–2004

The second phase spans from 1999 to 2004. On 15 July 2000, Zimbabwe launched The Fast Track Land Reform Programme (FTLRP) to speed up the pace of land acquisition and resettlement (Sachikonye 2005). In addition to the communal areas and the remaining LSCF areas, the FTLRP (2000–2002) increased the numbers of small-scale producers to over 145,000 through the A1 model and about 23,000 producers through small, medium and large-scale commercial farms of the A2 model (Matondi 2012; Moyo 2011; Scoones *et al.* 2011; Utete 2003). The decline in NDVI from around 1999 to 2004 is associated with the opening up of virgin and under-utilised land in the former LSCF areas. During an FGD, farmers in Ward 29 on 15 February 2020 indicated:<sup>vi</sup>

At the time of our arrival in this area, most of the lands were lying idle. Extensive thick forests covered what is now our village and fields, and so a lot of work went into tree cutting and land clearing as we settled in 2000. We were shocked to learn that, despite opposition to our settlement here, white farmers were barely using most of the land. Only cattle roamed in the fenced forests, with less than 200ha of the 2,500ha farm being used for crop production.

Studies in Zimbabwe have demonstrated that there was significant under-utilisation of a land in the large-scale commercial farming (LSCF) areas (Roth and Bruce 1994; Roth 1990; Weiner 1988). However, while there was a general decline in NDVI across all LSCF Wards, there is an increase in NDVI in Ward 30 between 1999 and 2004, as well as a decrease between 2004 and 2009. As BM, an indigenous large-scale commercial farmer revealed during a KII in August 2017, the cutting down of trees was not as extensive in their area compared to others because their farm, surrounded by an electric fence, protected over 2,000ha. Initially, the family wanted to venture into eco-tourism, specialising in wildlife management. However, some newly settled A1 farmers removed the fence in the mid-2000s, and this led to deforestation from 2005.

The FTLRP coincided with unfavourable macro-economic conditions and a general dip in production of all commodities, specifically production by large-scale white farmers of wheat, tobacco, soya beans and sunflower which experienced both reduced area plantings and output volumes (30–70 per cent). In addition, 2002–2003 was a poor agriculture season characterised by erratic rainfall, and many farmers got insufficient inputs for their requirements due to

foreign currency shortages, supply disincentives and the reduction of seed producers (Moyo 2004a). Furthermore, there was capital flight associated with economic sanctions (European Union 2002 and USA 2003) imposed on Zimbabwe (Ogbonna 2017; Kairiza 2012; Chingono 2010). These factors contributed to reductions in planting of the opened up lands in the land reform areas.

In the communal areas, the post-2000 era was characterised by an influx of former farm workers who did not secure employment or allocated land, and relocated to their communal areas (Moyo 2004a). Furthermore, some former farm workers who could afford land purchases went on to acquire land in the nearby communal areas. This exerted pressure on the already congested communal lands, resulting in more land area being cleared for opening up fields and thus low NDVI values; for example, only 0.15 in Ward 8 of Chiweshe communal area in 2004.

Support for tobacco production in the communal areas accelerated land clearance, both for production and curing. In 2000, TABEX Holdings Limited – which was linked to the United Kingdom and was contracting smallholder farmers – focused support on communal farmers, avoiding the resettlement areas due to sanctions. Furthermore, a FGD in Chiweshe<sup>vii</sup> revealed that, from 2002–2004 Agribank started giving loans to the communal sector, while in 2004, the Tobacco Industry Marketing Board started contracting farmers through loans.

## Phase 3: 2004–09

The third phase between 2004 and 2009 is characterised by a significant ( $p < 0.05$ ) (Table 4.1) increase in forest NDVI (Figure 4.2). Due to capital flight, there was a lack of investments/funds on the domestic front in the agriculture sector (both commercial and communal sectors), and a major economic deterioration occurred over this period. The resettled farmers failed to gain access to investment resources and finance, partly due to the insecurity of their land tenure (Moyo 2004b). Inflation soared from about 20 per cent in December 1997 to 623 per cent in January 2004 (RBZ 2007). Inflation continued to rise between 2004 and 2007, caused in part by the Reserve Bank of Zimbabwe's quasi-fiscal activities (Muñoz 2007). These activities included the provision of agricultural equipment and inputs such as fertilisers, transfers to parastatals, subsidised direct lending to banks and other companies, subsidised foreign exchange transfers and the purchase of military supplies and hardware (Center for Global Development 2014).

Zimbabwe formally entered hyperinflation, according to Cagan's (1956) definition, in March 2007 when month-on-month inflation reached 50.54 per cent and year-on-year 2,200 per cent (RBZ 2007). The newly settled farmers were able to cultivate only about 50 per cent of the total arable land allocated to them during this period, owing to shortages of tractor/draught power, fuel and investment in infrastructure/improvements and absenteeism on the part of some new settler beneficiaries, especially in the medium-scale A2 farm areas (FAO and WFP 2009).

In addition to the collapse of agriculture due to the economic conditions, a FGD in Mvurwi on 18 February 2020 suggested that the significant increase in forest cover from 2004 to 2009 in the now settled former commercial farms may also have been accentuated by the removal of illegal land occupiers in many areas by government officials from 2006 (Matondi 2012). From 2000, in addition to settlers who gained permits to occupy (offer letters) following the land reform, there were also many illegal land occupiers who settled mainly in forests in the new resettlement areas and other commercial farms that were yet to be allocated (for example for A2 medium-scale farms). Alongside the sanctioned settlers under the FTLRP, they opened up fields that led to a decrease in forest cover during this period. However, attempts to evict illegal land occupiers declined after 2006, and many illegal land occupiers have since settled in grazing areas and forests.<sup>viii</sup>

#### **Phase 4: 2009–18**

The turning point in the agricultural sector and the economy in general was at the beginning of the fourth phase (2009–18), after the signing of the Global Political Agreement (GPA). The GPA was an agreement between the Zimbabwe African National Union-Patriotic Front (ZANU-PF) and the two Movement for Democratic Change (MDC) parties. The Government of National Unity (GNU) in Zimbabwe was born on 11 February 2009.<sup>ix</sup> The GPA was concerned about the challenges that faced Zimbabwe and the multiple threats to the well-being of the people and therefore determined to resolve these permanently (Mukuhlanani 2014). With this accord, after 2009, the economy stabilised when a multi-currency system was introduced through the Short Term Emergency Recovery Programme (STERP), which addressed issues of runaway inflation and economic instability. Through STERP, the agricultural sector commodity marketing was liberalised.

By 2012, there was a surge in the numbers of tobacco contracting companies in Mvurwi, which by 2014 included Zimbabwe Leaf Tobacco, Chidziva, Boost Africa and TRIBAC/Shasha (Scoones *et al.* 2018).

Consequently, more farmers ventured into tobacco farming, taking advantage of the contract services and the ready availability of farming inputs in the local shops, resulting in a tobacco boom in Mvurwi (Scoones *et al.* 2018). This increased the demand for firewood for flue curing of tobacco and hence the resultant decline in forest cover from 2009 to 2014 became inevitable.

Furthermore, in 2013 the European Union relaxed its sanctions on Zimbabwe following the successful completion of the constitution-making process (Mukuhlanani 2014). The improved economic environment saw inflation dipping to below 5 per cent by 2013 (ZIMSTATS 2013). In addition, the liberalisation of agricultural commodity trade and the removal of restrictions on foreign currency retention resulted in increased agricultural financing through reinvestment of sales proceeds associated with contract farming (Shonhe 2018). The increase in agriculture financing motivated the newly resettled farmers and the communal farmers to open up more land for agricultural activities and, in the process, resulted in cutting of trees and a consequent decrease in forest cover.

The period from 2014 to 2018 experienced a significant decrease in forest cover, as shown in Figures 4 and 6. However, Figure 4.2 indicates that the rate of decrease was lower than that of 1999 to 2004 and 2009 to 2014. A FGD in Mvurwi in February 2020 highlighted that most of FTLRP beneficiaries had already settled during this period, and so the rate of clearing land for settlement and new fields was reduced. Gum trees and coal for tobacco curing were gradually introduced from 2012, reducing the impact on indigenous woodlands. Tobacco companies and marketing boards also advocated for the use of gum trees and coal, and supplied these to the farmers as part of contracts and environmental rehabilitation projects. Several gum plantations, notably in community-owned ones in the communal area of Ward 8 and individual ones across the study area, are growing and have had a positive impact on the forest cover of the area, as shown in Figure 4.2.

However, although there is reduced stress on trees, a more subtle deforestation with a bias towards bigger trees was still practised during the 2014 to 2018 period, and would not have necessarily shown up in simple land cover analysis. Electricity shortages that lead to load shedding was experienced across the Mvurwi area. Klls indicated that some people are illegally cutting trees (especially at night) for sale as a source of energy in Mvurwi and Concession towns. In Muswenede area of Ward 26, firewood is sold to Chiweshe communal area in support of tobacco production as well as other people, including *makorokoza* (illegal miners) in Rosa.<sup>x</sup>

Data in Figure 4.2 concur with those obtained by Masona (2014), who studied woodland NDVI in a Mashonaland East farm and recorded an increase in woodland NDVI from 1994 to 2000. However, from 2000 to 2005 the NDVI decreased and then increased up to 2009. Based on Figure 4.2, Ward 8 has the lowest forest cover throughout the study period. This concurs with the fact that communal areas have a higher population density and the most pressure on the land and natural resources, as compared to other areas that were once under LSCFs and are now resettlement areas.

### 5.1 Land cover and land use classification in Ward 26

As our overall assessment shows, many patterns can only be explained by reference to specific changes in particular areas. Our more focused study of Ward 26 provided granular data on NDVI and vegetation cover over the period under review.

Interviews conducted during field visits highlighted that LSCFs such as in Eastwolds/4 grew grass such as *katambora*, Kikuyu and star grass for use as hay during the first phase (1984–1999). The hay was used to feed mainly cattle and horses, which were reared in some farms such as Blanco. These areas were classified as grassland, but were intensively used. This is one reason why grassland occupied much of the area (averaging 50 per cent) up to 1999, as shown in Figure 4.4. Some of the LSCFs also did not rely on arable farming and fields. They had citrus plantations such as for granadilla, apples, lemons and oranges. Specific farms are Chidziva and Mondyness/B. Yet, through the NDVI analysis, these areas were classified as forests.

Water bodies did not experience significant changes throughout the study period. Figure 4.5 shows that the changes were within the range of 0 to 3 per cent of the total area. However, Musengezi dam, as revealed by the land classification in Figure 4.4, was built between 1989 and 1994, indicated by an increase in water body area. Few smaller dams were built as the years progressed, however.

During the second phase (1999–2004) the area under grassland increased from 51 per cent to 73 per cent, as illustrated in Figures 4.4 and 4.5. The decrease in area under forest (24 per cent to 14 per cent) and area under fields (22 per cent to 11 per cent) between 1999 and 2004 coincided with the FTLRP, which started in 2000. As discussed earlier, the programme led to the opening up of forest areas as new land beneficiaries occupied the newly allocated plots, but

in the first years land was not fully cleared and field areas remained limited. Indeed, on some former fields, bush and grass encroachment occurred. For example, in Pembi Chase farm near Mvurwi town this occurred as people took time to settle the new land and build new dwellings. Land invasions thus resulted in shifts in the classification from forest land to grassland or fields, but expansion of agriculture immediately after settlement in 2000–02 was limited (FGD, Pembi Chase farm, 25 February 2020). Besides maize, the new farmers started to grow tobacco, which needed timber for curing, resulting in a decline in forest cover.

However, there are some areas such as *vleis* (wetlands) in Mandindindi farm that were converted from grassland to fields as early as 2002. The same farm was originally a citrus plantation that grew guavas for export. However, some of these plantations were converted to fields during the 1999 to 2004 period. Figure 4.5 shows that there was a 41.6 per cent increase in area under fields from 1999 to 2018, as those occupying the land settled and expanded their farms. In the same period, forests recorded a 44 per cent decrease. There was no change in area under grassland and water. However, there is a difference between the spatial distributions of land cover over this period. For instance, some areas that were under grasslands in 1999, such as the *vleis* in Mandindindi farm, were converted to fields by 2018. Some areas that were forests (natural forests, gum or citrus plantations) in 1999 were converted to grasslands or fields.

However, there were a few plantations (especially those in Forester J Estates and south eastern side of Pembi Chase) that remain managed as plantations. Some former citrus plantations (such orange plantations near Musengezi dam in Sandford farm) are however experiencing invasion by other tree species such as *Lantana camara*, yet are still recorded as forests. Other plantations, such as in Mondeneys/B and Blanco farms, were recorded as forests or grasslands in 1999 but they were fields by 2018. In other words, the land invasions and subsequent settlement across the area of former LSCFs resulted in major changes in land cover/land use within the study period, with land reform not surprisingly resulting in an increased area of fields and a decline in forest cover. As the analysis of changes in Ward 26 shows, periods of economic crisis affect agricultural production; the area under fields fell drastically in 2004 and later rose as economic stability returned from 2009, eating mainly into grasslands (Figure 4.5).

## 6 CONCLUSION

Our study has shown that land use change across Mvurwi has not been one of linear transformation due to secular change in factors such as population or climate. Instead, shifts have occurred with both increases and decreases in forest cover over time. This is the result of shifts in the wider political and economic context, which drives land use change but in a non-linear manner. Environments are always entwined with a wider political economy, and in the turbulent period since 1984, Mvurwi is no exception. We identified five phases, which were identified by an examination of NDVI changes over the whole study area, as well as through the more granular analysis within Ward 26. Insights from interviews and FGDs across the area<sup>xi</sup> helped identify the land use change drivers.

Ground-truthing through interviews and discussions in the field is essential to gain a full picture. Thus, combining NDVI analysis of LULCC using satellite-based imagery with insights from a grounded political economy analysis reveals how environmental changes reflect an interplay of socio-economic, political and environmental factors.

Our analysis highlights, too, that environmental changes are not just the result of local land users' choices. The wider macro-economic and political situation has a huge impact. For example, the contraction of commercial farm fields in the 1990s was linked to growing incentives to focus on high value crops for export, which required smaller land areas but increased capitalisation, such as for horticulture and floriculture. Similar incentives resulted in a shift to wildlife harvesting, which meant an expansion of forested areas, reducing the area of cropped fields. Equally, the period of hyperinflation in the 2000s, or the lack of government support after ESAP, saw a contraction of agricultural production and reduced levels of field expansion. The effects of climate change will likely continue to be heightened variability in rainfall, with drought shocks combining with wider political and economic drivers in particular ways to create shifts in land use, rather than seeing a simple, uni-directional change over time.

Over the last four decades, land use in Mvurwi area has changed dramatically. Clearly, the land reform has been the major shift, but there have been others, all combining in a complex way to result in a highly variable pattern that shows shifts back and forth in land cover categories in a spatially heterogeneous way. Our study therefore challenges any simplistic, linear interpretation and argues for an analysis of environmental change, focused here on land cover and land use, to be combined with a grounded understanding of political economy over time. Multiple drivers intersect and environmental change must therefore always be understood as co-constituted with social dynamics and political economy.

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# ENDNOTES

- i In the field of vegetation mapping, the most commonly applied sensors include Landsat (mainly TM and ETM+), SPOT, MODIS, NOAA–AVHRR, IKONOS and QuickBird (Xie, Sha and Yu 2008).
- ii The android-based questionnaire was guided by the following questions:
1. Date
  2. Starting time
  3. Interviewee number
  4. Ward 26
  5. Farm name
  6. Plot number
  7. Household name
  8. Designation
  9. Sex of respondent
  10. Age of respondent
  11. Marital status
  12. Level of education
  13. When did you start staying in the area?
  14. Primary occupation
  15. Secondary occupation
  16. Number of people in the household
  17. GPS coordinates
  18. Why did you choose to be resettled or to acquire a plot of land? What was your decision making? Who made the decision or who/what influenced you?
  19. How did you get the ownership of the plot? (Land ownership type (rental, lease, permit, nothing)). If renting can they explain how they entered into the rental arrangement, what agreements were signed, do they pay some form of rent/what is the arrangement?
  20. What was the initial size of land you cultivate when you arrived on the plot? Which is the area? Where there any changes on size of the cultivated land up to now? What influenced the change or absence of change?
  21. What was the land use or land cover when you resettled? Which changes in the state of the land occurred, if there is any and when is that?
  22. Can you tell us the type of crops that you have been growing since resettlement?
  23. If you grow tobacco, when did you started doing that? What do you use for curing and where do you get the materials?
  24. What motivates you to engage in that type of farming activity?
  25. Can we have a discussion of the maps of this area which show the state of the land over several years back? Can you tell us what is happening, do you think it's true?
  26. Why do you think we are seeing these changes in the map, what is causing this pattern?
  27. What kind of trees is found in this area? Are there any that you think are disappearing and is so, which ones are these?
  28. Are there any sacred areas of this farm or this area where trees are not permitted to be cut? Where are they? Would you be able to show us? Why is it sacred?
  29. Are there any specific trees best suitable for tobacco curing in these areas .If there are any, are they found in this area, if not where do you get them?
  30. What is your main energy source and where do you obtain it from?

31. In your own view, do you think land cover (grassland, forests, field, waterbodies) in this area has changed? What are the main reasons behind these changes?

32. Is there anything of importance that you would like to tell me, that would help this research?

- iii FGD, Chiweshe, 22 February 2020
- iv FGD, Hariana, 23 February 2020
- v Personal interview with WS (Wadzanayi Saburi), 26 February 2020
- vi FGD, Farmers in Ward 29 on 15 February 2020
- vii FGD in Chiweshe, 17 February 2020
- viii Personal interview, KN, 19 February 2020
- ix The GNU emerged out of mediation by Thabo Mbeki the then South African president. Negotiations started in September 2008 and it subsequently resulted in the signing of the GPA on 15 September 2009 by R.G Mugabe (ZANU-PF), M. Tsvangirai (MDC-T) and A. Mutambara (MDC-M)
- x Personal observation, 25 March 2020
- xi FGD, Pembi Chase farm, 25 February 2020

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