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On the relationship between land tenure and land degradation.

A case study in the Otjozondjupa Region (Namibia) based on satellite data

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On the relationship between land tenure and land degradation. A case study in the Otjozondjupa Region (Namibia) based on satellite data

Pablo Gilolmo[1] *& Agustín Lobo*[2]

Abstract

Discourses promoting the privatization of communal land sustain that it necessarily implies a higher degree of environmental degradation as a result of its presumed lack of economic rationality and subsequent inefficient use of natural resources. Livestock-based rural economies on arid and semi-arid regions are blamed for poor grazing strategies, high stocking rates and a "free for all" character, all supposedly concurrent with communal tenure. Namibia is a comfortable niche for this rationale, which in the Otjozondjupa region arguably underpins tangible privatization-like policies. Although Hardin's assumptions have already been challenged, the debate is still high on the agenda of international institutions, since policies and interventions promoting privatization still find justification on them. The aim of this paper is to add evidence to this discussion through a case study in a semi-arid region where livestock is the main agrarian activity. We classified land tenure polygons according to climatic conditions in the Otjozondjupa Region (Namibia) and run a stratified analysis of time series of Normalized Difference Vegetation Index (NDVI) from the Global Inventory Modeling and Mapping Studies (GIMMS). The resulting trends show no evidence of increased surface degradation in communal lands versus other land tenure types and yet, in half of the cases analyzed, plant productivity trends are significantly worse in private lands when compared to open communal land. In this way we show how accurate knowledge about land degradation can contribute to an environmental approach committed to social and agrarian justice.

Key words: NDVI, environmental degradation, Namibia, tragedy of the commons, land tenure.

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INTRODUCTION

According to the Food and Agriculture Organization of the United Nations, Namibia, the driest African nation south of the Sahara desert (Nana-Sinkam, 1995), is one of the world's most prone countries to suffer from desertification. Arguments promoting the privatization of the commons in the rural world exist since the expansion of the so-called “green revolution” in the 1960's, and are well known thanks to, e.g., Hardin's famous formulation of the *Tragedy of the Commons* (1968). One of the stances of such a discourse is that communal land tenure implies, necessarily, a higher degree of environmental degradation as a result of its presumed lack of economic rationality and subsequent inefficient use of natural resources (e.g. World Bank, 2003; Deininger, Selod, & Burns, 2012).

In arid and semi-arid regions with livestock-based rural economies the blame goes to poor grazing strategies, high stocking rates and a “free for all” character, all supposedly concurrent with communal tenure (Ellis & Swift, 1998). Such a current of thought utilizes this argument to advise formulas of individualisation of land rights or privatisation in order to improve economic rationale and, in consequence, to attain better preservation of the land and its associated resources (i.e. vegetation) (HIC, 2003). Namibia is a comfortable niche for this rationale, which in the region under study arguably underpins privatization-like policies (c.f Gilolmo, 2014a: 53-63; Gilolmo, 2014b; Mejis, Hager & Mulofwa, 2014).

The Commodification of land, including privatization, has been counter-argued and resisted in Southern Africa and many other parts of the world as contributory to poverty increase, dependency deepening, social clash, rural depopulation and ultimately growth of urban slums (i.e. Moyo, 2008: 21; Borras & Franco, 2010). As a result, the discussion around the suitability of privatization in the South is highly controversial. Although the debates about land tenure and agrarian development comprise social, economic and political dimensions, global climate change and resource depletion rise the environmental concern as a paramount one. While Hardin's assumptions have been already challenged and the scientific debate around the causal relation commonality-degradation is very much alive, policies and interventions promoting privatization still find justification in it (i.e. Mejis, Hager & Mulofwa, 2014). The aim of this paper is to add evidence to this discussion through a case of study in semi-arid region where livestock is the main agrarian activity.

METHODOLOGICAL BACKGROUND

Field-based investigations have applied a wide range of different methodologies to study vegetation changes, but they are limited by sample size and by too short a time span, relative to the phenomenon under study (Riebeek, 2007). For the particular case of Namibia, most of studies based on the distribution of sampling point sites tend to conclude that there are high rates of land degradation in communal lands (e.g. Strohbach, 2001). But there are also studies that, determinedly comparing land tenure types, show otherwise. David Ward et al. (1998) conducted a study in the communal area of Otjimbingwe (Namibia) and the surrounding private farms to compare vegetation condition between both tenure types. Their methodology was based on the principle than under equal environmental circumstances, differences in vegetation condition should be attributed to differences in livestock management. They sampled 10 placements, and measured grass height and density once a year for three consecutive years (1996, 97 and 98). They also analyzed soil quality by measuring nitrogen, phosphorus and organic carbon. Their results show that there are no significant differences in plant and soil condition between both tenure types, thus concluding that land degradation is not a necessary outcome of communal tenure in their region of study.

Other, not Namibian-specific, studies point in that direction. Daniel W. Bromley has published extensively about common property, including the causes of resource degradation under these regimes (Bromley, 1990; 2008a; 2008b). Rather than considering degradation as a result of the common property regimes themselves, he finds external factors such as institutional decay to be the causes. In a pioneering work, Ellis & Swift (1988) attempted to demonstrate that plant productivity in arid and semiarid environments is mainly dependent on abiotic factors (specially rainfall), rather than on internal feed-backs (i.e. over-exploitation of resources by predator or herbivores, i.e. livestock, grazing management). They argued that, consequently, these environments are not potentially equilibrial, but persistent, and therefore the strategies of pastoral societies do not aim to preserve any equilibrium but to adapt to high variability and stay resilient themselves. This new paradigm inspired some works (like Ward's) aiming to check if differences in land systems and livestock management (i.e. tenure) where causally related to environmental degradation.

The limitations of studies exclusively based on field methods remained until the development of Remote Sensing technologies (RS), which allow periodical observations over vast areas (actually, the entire earth surface) at increasingly high resolution. Products resulting from space missions for earth observation are capable to reach more exhaustive sampling through consistent and extensive measurements in space and time. Resulting estimates of total standing biomass and plant productivity have led to more precise measurements of vegetation dynamics. Calculations of plant productivity based on these measurements along prolonged time series and over large areas can put in evidence degradation process as a negative trend over a long period of time (Riebeek, 2007).

Archer (2004) and Wessels et. al. (2007; 2012) are among the many authors who have used remote sensing and NDVI attempting to measure land degradation in Southern Africa. Both are concerned on differentiating human impact from rainfall effects on vegetation variability. However, these models are data demanding and theoretically challenging. Furthermore, not only rainfall, but also different land covers and species distributions in different locations may imply different responses to rainfall in terms of plant productivity. Therefore, residual differences do not represent human impact in a consistent way through various locations, as Wessels at al. (2012) themselves point out.

Several researchers have used Remote Sensing to study topics related to vegetation changes in Namibia. Espach et al. (2010) developed a method to estimate annual changes in grazing capacity (avoiding the fixed estimates normally applied) combining NOAA, Landsat and SPOT data. Wagenseil and Samimi (2007) formulated a model to calculate the extent of woody cover on the Namibian savannah using multi-temporal NDVI data calibrated through Landstat ETM data. However, whilst these studies look at particular aspects of vegetation change, they do not aim to use RS in order to measure the degree of overall land degradation and its relation with human activities.

In our case, as we do not attempt here to find the precise causes of degradation sensu Wessels, but only to compare between land tenure types, we have opted to recall Ward's principle of comparing areas of similar biotic and abiotic conditions, therefore looking directly at the differences derived from the tenure variable, not modeling mediated. Our objective is to elucidate if there are significant differences in plant productivity trends among land tenure types. The following pages will aim to establish the degree of land degradation on areas under different forms of land tenure in the Otjozondjupa Region. The objective is to make an empirical comparison between land degradation under private and communal land tenure. The expectation is to obtain some conclusions about the human causes of land degradation and the validity of the dominant arguments posed above. The research question at this point is: *Under which land tenure has land degraded more?*

METHODS

a) Definitions

Land degradation and desertification is a process difficult to define, difficult to asses, and even more difficult to quantify (Riebeek, 2007). According to the United Nations Convention to Combat Desertification (UNCCD), “"desertification" means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities” (UN, 1994). However, this definition gives little indication of what needs to be measured in order to identify desertification. For that reason, researchers in this field have developed more practical approaches.

Reckoning that the amount of existing vegetation in a given area at a given moment is defined as total standing biomass, while annual biomass productivity is the amount of carbon fixed from CO_2 to organic material by area and year, the NASA Earth Observatory defines desertification as “a reduction in the *productivity* of the land that is not reversible. In other words, land is desertified when it can no longer support the same plant growth it had in the past, and the change is permanent on a human time scale” (Riebeek, 2007, the italics are ours). Therefore, it can be a significant contribution to elucidate the initial question by using annual biomass productivity as an indicator of land degradation.

Green plant biomass absorbs part of the solar radiation during photosynthesis ('Photosyntetically Active Radiation' – PAR) in the blue and red bands of the electromagnetic spectrum but it is very reflective in the near infrared region. Thus, satellite sensors producing multi-spectral images by measuring the solar light reflected by earth in the visible and near-infrared region can provide information about the amount of light absorbed by plants. One of the most common products obtained from reflectivity data is the Normalized Difference Vegetation Index (NDVI). NDVI is calculated as the normalized ratio of the difference of reflectance between the near-infrared and red bands, and thus it is a proxy of the amount of green plant cover present in each pixel of the image in a given moment, although it is also affected by plant types and condition. NDVI values along weekly or, at most, monthly intervals can provide an estimate of the dynamics of the amount of vegetation cover that is present to intercept PAR, thus providing essential information to estimate annual plant productivity. NDVI annual courses respond to climate variability, in particular precipitation and length of the growth season, as well as to direct and indirect human impacts on vegetation cover.

Several facilities for the processing of space data calculate and make publicly available global time series of NDVI. The widely accepted GIMMS data set (Pinzon, Brown, & Tucker, 2005; Tucker et al., 2005), has been chosen for this study, as it provides a long-term set of bi-weekly composited images that decrease noise caused by cloudiness in daily images and have undergone radiometric calibration, atmospheric correction, cloud screening, and solar zenith angle correction, reducing the effects of volcanic aerosols, water vapor, and the differences among sensors covering the period. This processing results in a very consistent time series.

b) Design of the study

There is a methodological debate in relation to NDVI as a means to infer plant productivity and land degradation (Wessels et al. 2007; 2012). They criticise both, the possibility of relating annual plant productivity to the causes of desertification, as well as the validity of NDVI to measure plant productivity, specially in arid and semi-arid areas. According to them, effects of high rainfall variability are impossible to distinguish from human-induced changes in plant productivity, while the relationship between actual plant productivity and NDVI vary between different environments, biasing any intended comparison. Therefore, since annual biomass productivity is affected by numerous environmental factors, of which precipitation and vegetation variability are of paramount importance in the area of study, retrieving the footprint of human management from within a dataset of annual biomass observations requires a data analysis strategy able to isolate the eventually minor but time-consistent human effect.

Any single comparison of the annual productivity at two given years, even if distant in time, cannot be used as an indicator of the impact of human management because the great inter-annual variability in precipitation causes large inter-annual variability in annual productivity. Furthermore, differences on vegetation types and land covers imply differences in biomass productivity (even under equal rainfall conditions) (Wesels, 2007). Both factors (rainfall and vegetation types) often preclude the isolation of observable human impact. An observed trend in the time series of biomass productivity can only be attributed to the impact of management if the long term variability of climate and vegetation factors in time and space is taken into account.

In order to isolate the trend caused by the human factor, rainfall and vegetation effects could be filtered out by subtracting the predictions of a climate-vegetation model (as Nicholson et al. [1998] or Prince et al. [1998], both cited in Wessels et al. [2007] propose), but modelling the effect of climate on annual productivity is theoretically challenging (Wessels et al., 2007; 2012), technically difficult and data demanding. Therefore, this study adopted the more pragmatic solution of stratifying the area of study into zones within which climate and vegetation are assumed to be uniform. Given the these considerations, the aforementioned research question is reformulated as: *Are there differences in the trends of annual biomass productivity among different forms of land tenure within zones of uniform vegetation and rainfall conditions?*

The annual sum of NDVI is a proxy of the annual capacity of green vegetation to intercept PAR, and as irradiance is not a limiting factor in the study region, the annual sum of NDVI of a given pixel is closely related to the annual plant productivity at that pixel. Estimating actual productivity values is difficult, because the relationship between annual NDVI sums and annual biomass productivity depends upon the type of vegetation and is thus subject to many potential inconsistencies across different geographic locations (Wessels et al., 2007; 2012). Nevertheless, the goal here is not to evaluate plant productivity, but to analyse its inter-annual variability. Time series of annual changes of NDVI at the same site can be considered much more linear with annual changes of biomass productivity. Therefore, a positive (or negative) trend in the time series of annual NDVI anomalies for a given site indicates a positive (or negative) trend in annual biomass productivity. In this paper annual sums of bimonthly NDVI observations are the surrogate of annual productivity and we refer to them as "annual NDVI" (NDVIan). Thus, our research question adopts the following operationally testable formulation: *Are there differences in trends of the anomalies of annual NDVI ("NDVIan") among different forms of land tenure within zones of uniform vegetation and rainfall conditions?*

c) Description of the research data

In order to answer the research question, three sets of data are needed: the first is the dataset regarding plant productivity *(NDVI)*. The second one is related to the *environmental factors* (climate, vegetation types and land cover) that will be used for the stratification. The third is the spatial characterisation of the *land tenure* structure.

NDVI: As mentioned in previous sections, we approximate the inter-annual variability of plant productivity from the annual sum of the bi-weekly NDVI data GIMMS data (Pinzon, Brown, & Tucker, 2005; Tucker et al., 2005). We analyze a 19 years-long (1982-2000) series of NDVIan, which allows to study inter-annual variability during this time period in every pixel, and to statistically calculate their trends.

ENVIRONMENTAL FACTORS STRATIFICATION: The large size of the region implies that a simple comparison of trends by land tenure types could be distorted by different natural conditions. The main natural variable affecting plant productivity in this region is rainfall. Also, the relationship between NDVI observations and plant productivity is affected by vegetation type. Vegetation type depends on life-form composition (closely linked to species composition) and structure (land cover). As randomizing tenure types is obviously impossible, we have chosen to stratify the analysis, so comparisons only take place between zones of similar natural conditions (ZSNCs). A disadvantage of this approach is that there might be areas with no possible comparison, since a ZSNC may be occupied by a single type of tenure, as it occurs in some of our cases.

In order to define our ZSNC, we use the maps of plant types and land cover from Mendelsohn (2009)[3]. Stratifying by areas defined according to precipitation and temperature is almost impossible, given the scarcity and biased distribution of observatories. We assume that the strong relationship existing between vegetation and climate (Walter, 1973; Woodward, 1987) allows for the utilization of the former as an acting proxy of the latter. Therefore, we have combined Mendelsohn's maps on land cover and plant types distribution, delineating in this way the ZSNCs (Figure 1). Combining maps of land cover and plant types is very likely resulting in an over-fragmentation, with some areas that are actually uniform being split in several tiles, which increases the danger of having too few farm polygons for some strata. Nevertheless, we have preferred this to the risk of having climatically

[3] Shapefiles availabe at the Environmental Information Service of Namibia (EIS), http://www.the-eis.com/

heterogeneous strata.

LAND TENURE: Tenure mapping results from a study which comprised a combination of sources to establish the type of tenure at every farm or area (for a detailed description see Gilolmo, 2014a: 29-63). Private land was classified according to information form cadastral and agricultural maps, and cleaned out to exclude urban, military and church land among other cases not considered for the analysis. Tenure types of communal lands were established according to previous estimations, cadastral and archival information, personal interviews and field work. Figure 2 depicts the result of this process in a single polygons for each tenure types, as well as and how they match each ZSNC.

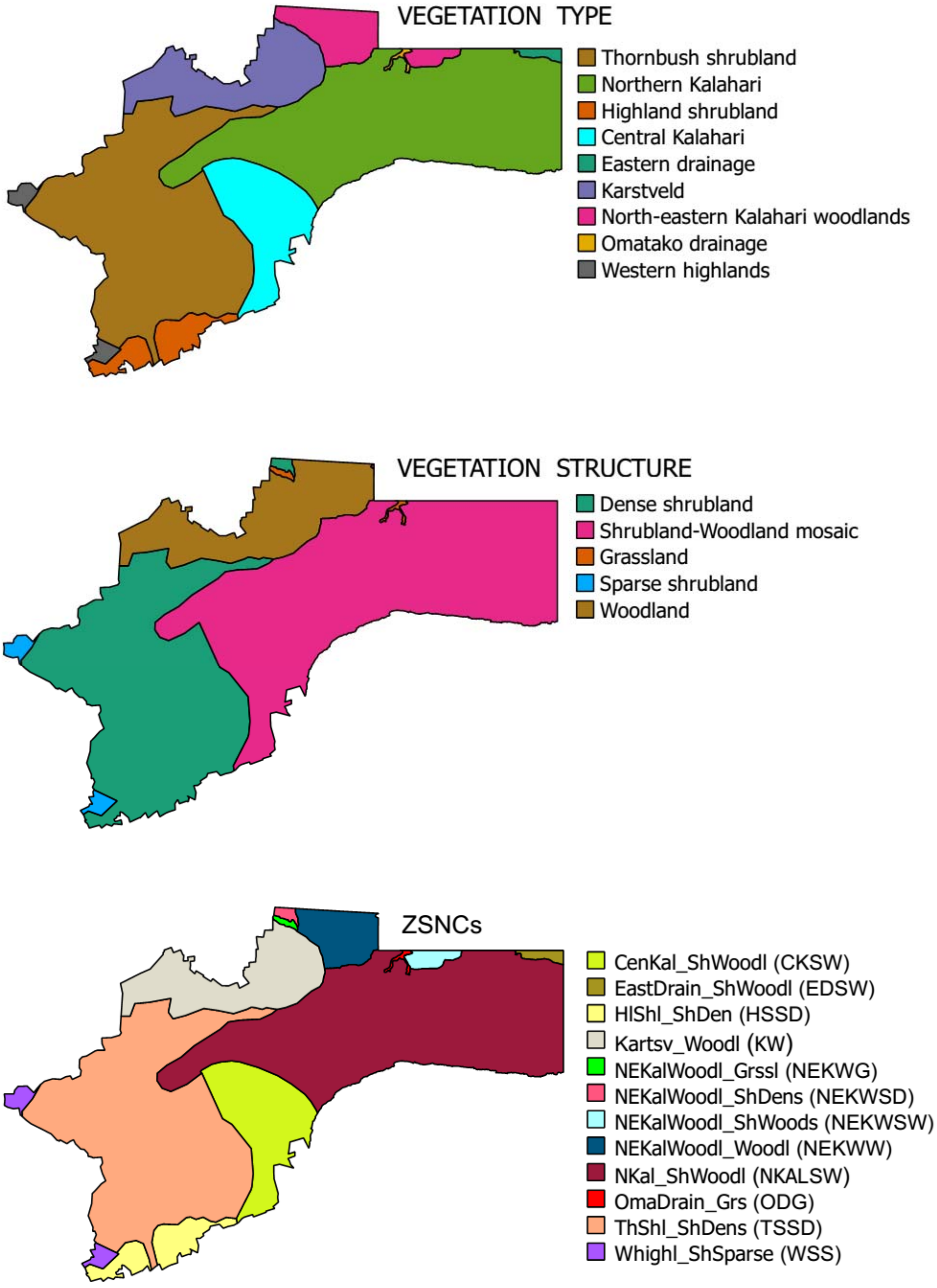
d) Data analysis

24x19 bi-weekly NDVI layers at 8 km x 8 km resolution from 1982 to 2000 were downloaded from the GIMMS website, clipped to the study region, and NDVI values added up by year, which resulted into a data cube of 173 x 1881 pixels x 19 annual NDVI layers. Observations with a quality flag indicating unreliability were labeled as NA and not used in the analysis. Layers of ZSNC and Land tenure polygons were overlaid on the data cube and extracted into a data table of 1554 rows (pixels) x 23 variables (pixel code, farm code, land tenure type, ZSNC and 19 annual NDVI values). Data handling and statistical analysis was performed in *R* (R Core Team, 2013), writing the necessary scripts to proceed with the statistical analysis, consisting of:

i) Time series of medians: We calculated the medians of NDVIan by land tenure type and by ~~the~~ ZSNC~~s~~, to get a first visual approximation to their evolution along the time period under study. Lines linking the annual median values of NDVI sums simplify the visualisation of the differences among land tenure types along time.

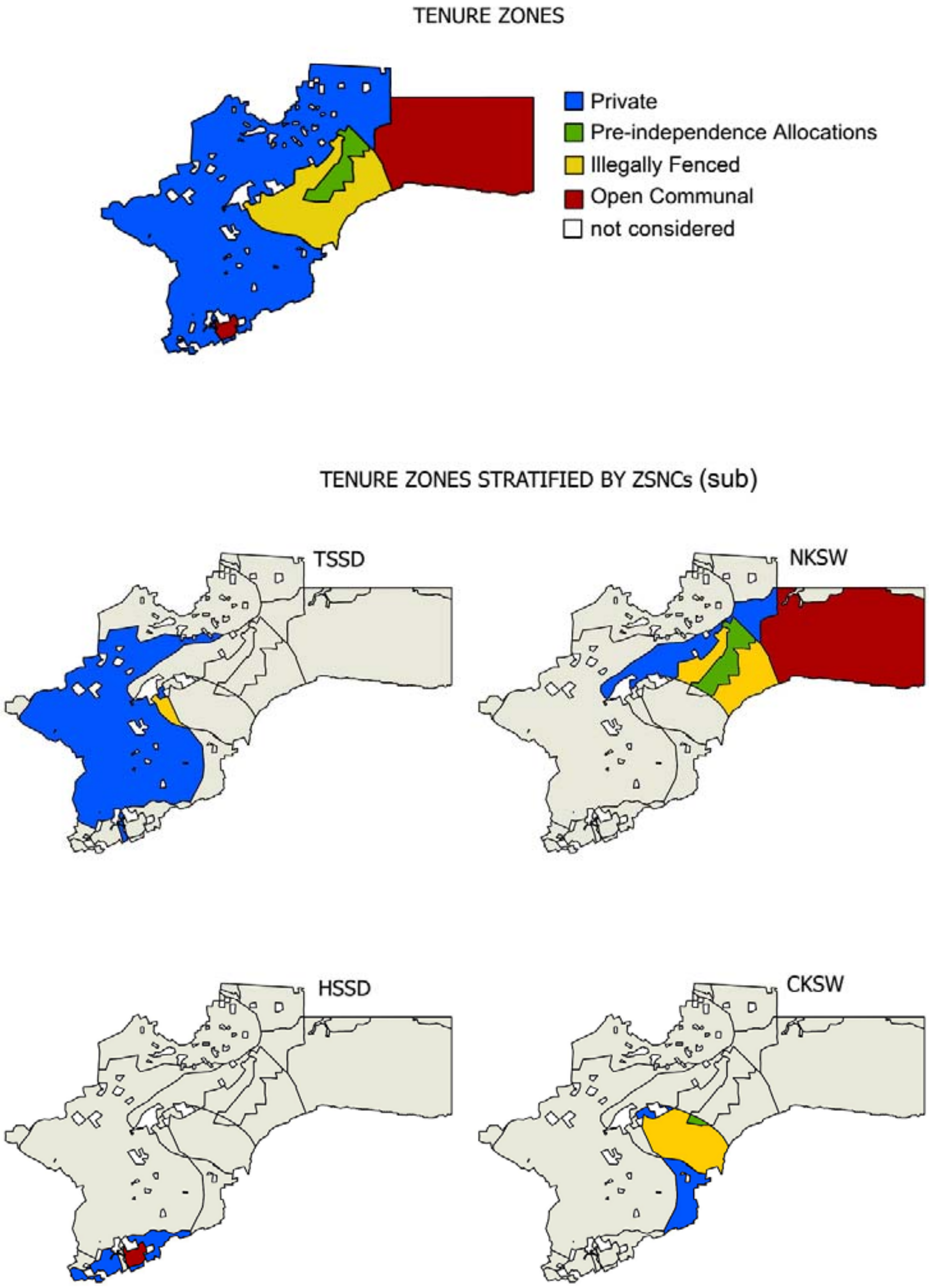
ii) Time series of anomalies: For each pixel, we calculated the median of the 19 annual NDVI values and the annual anomaly as the difference between the annual NDVI values and their respective median.

Fig. 1



Source: EIS, Gilolmo (2014)

Fig. 2



Source: EIS, Gilolmo (2014)

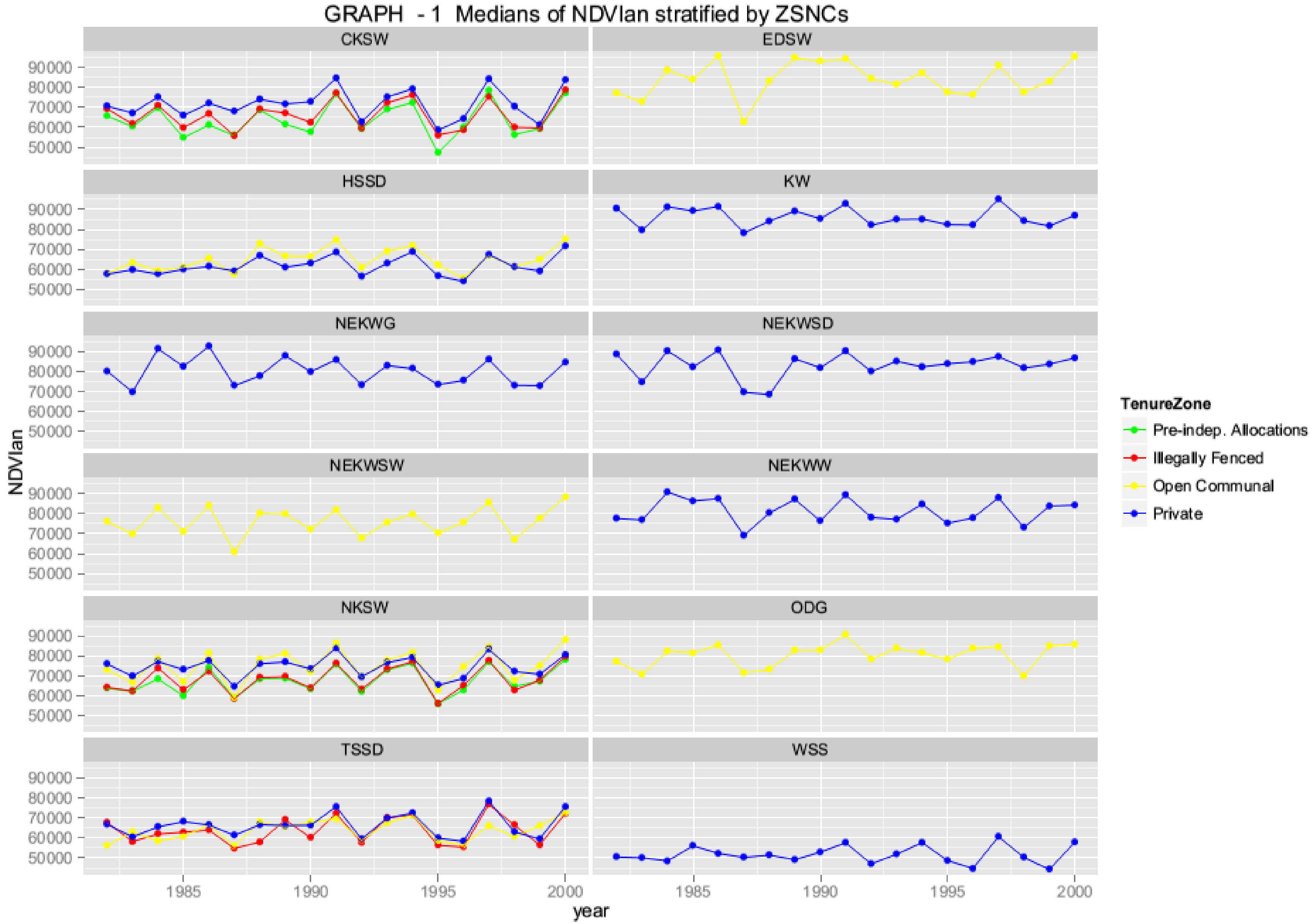
iii) Calculation of linear trends: We Calculated the trends of the anomalies of annual NDVI for tenure types stratified by ZSNC through linear regression models noting in each case the significance of the R^2 (F-test, which tests the null hypothesis of the proportion of variance accounted for by the model being significantly different from 0) and the t-test of the slope (which tests the null hypothesis of the slope being significantly different from 0). In both cases we applied the customary 5% threshold, which is the highest acceptable probability of being wrong if rejecting the null hypothesis.

iv) For those cases in which trends were significant (that is, both R2 and slope were significant) and for each ZSNC, we tested whether the slopes of the land tenure types were different. In order to do so, an analysis of covariance of every pair of tenures to compare is conducted at each ZSNC. The analysis of covariance implies looking at the interaction between two linear regression models. In practice, the p-value of the covariance analysis equals to testing the significance of the difference between the slopes of the two samples analysed (Crawley, 2005 pp. 187-194). Again, the limit to consider it significant is 0.05,

RESULTS

Graph 1 shows time series of medians of NDVIan by land tenure types and by ZSNC. KW and EDSW presented the highest values of annual NDVI for the period of study, while WSS, HSSD and TSSD presented the lowest ones. Because some ZSNC are too small, only 4 included more than one land tenure type: CKSW, HSSD, NKSW and TSSD. There is no common pattern of plant productivity *vs*. tenure across zones: while Private lands have higher NDVIan than the rest of land tenure types in CKSW, this is not the case on HSSD, NKSW or TSSD.

Graph 2 shows the linear trends of anomalies of annual NDVI for each land tenure type and stratified by ZSNC. Only those ZSNC in which more than one tenure type are presented. In all cases, trends are either not significant or positive (Table 1). Trends that are not significant (both R2 and slope not significant) are found for pre-independence allocations of CKSW and open communal of TSSD (see shaded fields in Table 1). This might seem surprising, as the respective slopes are the highest, but note that the standard errors of these slopes are very high, probably because the number of involved observations is too small. The rest of trends, all present increasing slopes significantly different from 0.



GRAPH - 1 Medians of NDVIan stratified by ZSNCs
CKSW
EDSW
HSSD
KW
NEKWG
NEKWSD
NEKWSW
NEKWW
NKSW
ODG
TSSD
WSS
NDVIan
90000
80000
70000
60000
50000
year
1985
1990
1995
2000
TenureZone
Pre-indep. Allocations
Illegally Fenced
Open Communal
Private

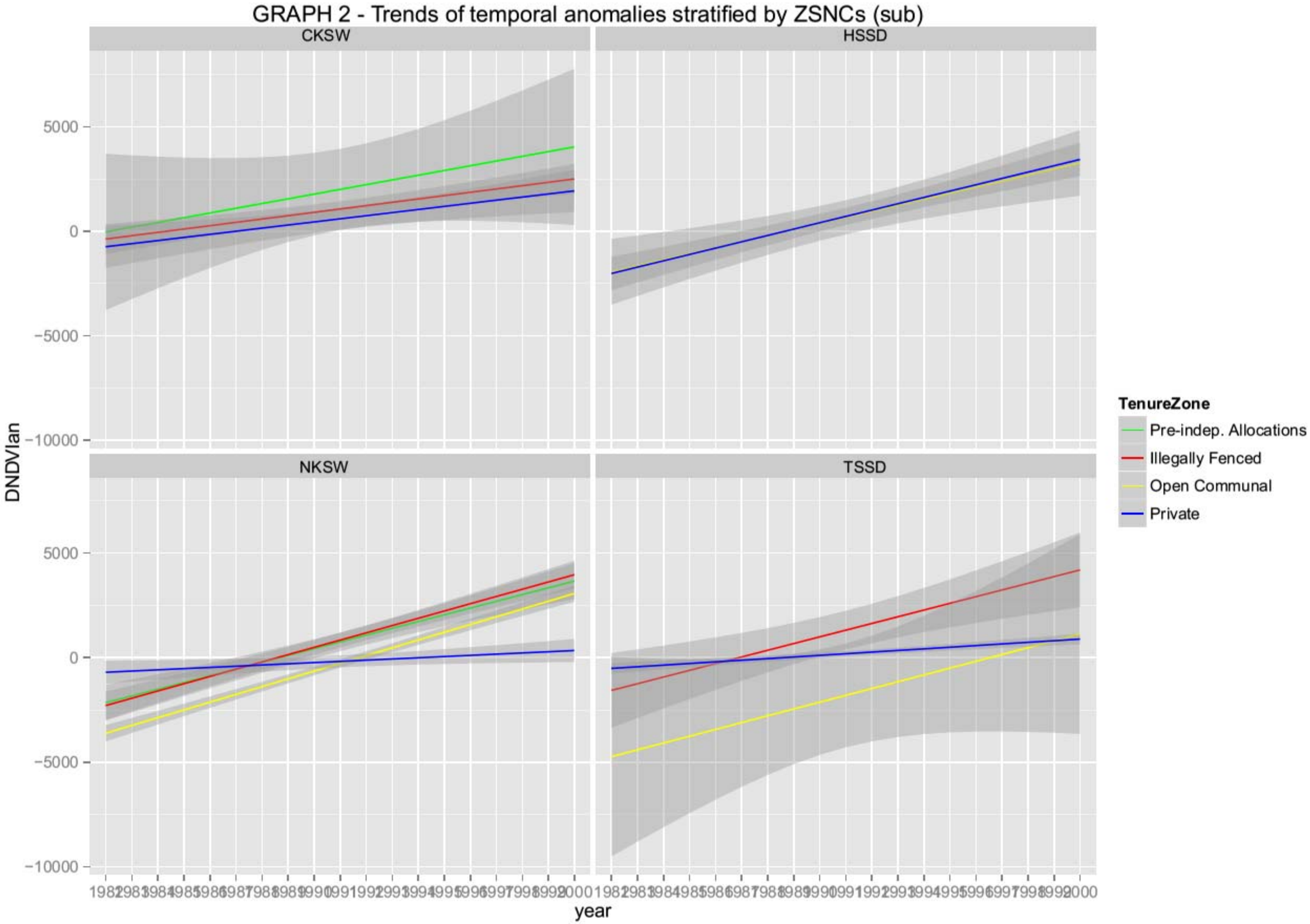

GRAPH 2 - Trends of temporal anomalies stratified by ZSNCs (sub)
CKSW
HSSD
NKSW
TSSD
DNDVIan
year
5000
0
−5000
−10000
TenureZone
Pre-indep. Allocations
Illegally Fenced
Open Communal
Private

Table 1: Regression models and tests of significance

ZSNCs	Tenure type	n	Slope (standard deviation)	t-test	R²	F-test
CKSW	Private	874	148.59 (48.85)	<2e-16	0.0105	0.002421
CKSW	Open Communal	-	-	-	-	-
CKSW	Illegally Fenced	1691	159.77 (34.65)	<2e-16	0.01243	4.317e-06
CKSW	Pre-indep. Allocations	76	226 (178)	0.21	0.02131	0.2083
HSSD	Private	684	303.12 (38.67)	<2e-16	0.08265	1.751e-14
HSSD	Open Communal	190	289.45 (75.76)	<2e-16	0.07205	0.0001807
HSSD	Illegally Fenced	-	-	-	-	-
HSSD	Pre-indep. Allocations	-	-	-	-	-
NKSW	Private	1900	57.79 (26.85)	<2e-16	0.002435	0.03149
NKSW	Open Communal	6973	371.37 (19.06)	<2e-16	0.05164	< 2.2e-16
NKSW	Illegally Fenced	1710	347.91 (32.61)	<2e-16	0.06248	< 2.2e-16
NKSW	Pre-indep. Allocations	836	323.54 (41.44)	<2e-16	0.06811	1.75e-14
TSSD	Private	9519	77.91 (12.29)	<2e-16	0.004207	2.384e-10
TSSD	Open Communal	19	325.9 (214.9)	0.148	0.1192	0.1477
TSSD	Illegally Fenced	209	320.25 (86.02)	<2e-16	0.06276	0.0002538
TSSD	Pre-indep. Allocations	-	-	-	-	-

Table 2: Interaction tests

ZSNCs	Interacting Tenure Types	Interaction Tests	p-interac.	#
CKSW	Private 'vs' Illegally Fenced	-11.19	0.851	**1**
HSSD	Private 'vs' Open Communal	13.67	0.87	**2**
NKSW	Private 'vs' Illegally Fenced	-290.12	5.34e-12	**3**
NKSW	Private 'vs' Open Communal	-313.58	1.22e-15	**4**
NKSW	Private 'vs' Pre-indep. Allocations	-265.75	6.08e-08	**5**
NKSW	Open Communal 'vs' Illegally Fenced	23.46	0.574	**6**
NKSW	Open Communal 'vs' Pre-indep. Allocations	47.84	0.400	**7**
NKSW	Illegally Fenced 'vs' Pre-indep. Allocations	24.38	0.657	**8**
TSDS	Private 'vs' Illegally Fenced	-242.34	0.003876	**9**

The interaction tests of Table 2 indicate that there are no significant differences between the trends of Private lands and Illegally Fenced (in CKSW), and Open Communal (in HSSD), while the trends of Private lands are significantly different (actually smaller) than those of the other land tenure types present in NKSW and TSDS (see shaded fields in Table 2). Furthermore, in NKSW the trends of Open Communal, Illegally Fenced and Pre-independence Allocations do not present significant differences among them.

DISCUSSION

1. Desertification and positive trends: Given that Namibia is widely acknowledged to be in a process of desertification, it might be surprising that all trends are positive. A possible explanation would be that these trends are calculated in a period starting with a prolonged drought (1979-1987 y 1992-1993). As long as precipitation is the main factor affecting plant productivity in the area of study, it seems logical that a time series starting with low precipitation followed by normal levels must result in a positive trend. Thus, this does not mean that Namibia is not desertifying, but to prove such desertification data for a much longer time period would be needed (especially data covering the years preceding the 1980s dry period) which, unfortunately, are not available. In any case, as long as the main factors which can cause variations in plant productivity and its measurement through NDVI (climate and vegetation) are cancelled (as the stratification did), the results for the different tenure zones allow meaningful comparison. The results show that there are definitely tenures that, studied through the same methodology, show higher NDVI increases than others. Thus, it can be affirmed that there are tenure zones that reacted better than others to the same climatic conditions. In addition, it can be affirmed that there are tenure zones that increased their plant productivity more than others.

2. Tenure and desertification: NDVI trends (Graph 2 and Tables 1 and 2) show that in two of the four ZSNCs (NKSW y TSSD) plant productivity increased significantly less in private land than in the other tenure types. In the other two ZSNCs (CKSW y HSSD), plant productivity increased in a similar way when comparing private and other tenure types. In those ZSNCs where a direct comparison between private tenure and open communal tenure is possible, there is one case of similar increase (HSSD), while in the other case (NKSW), open communal tenure shows a significantly higher increase than private tenure. Notably, Graph 1 showing median NDVIan values, indicates that plant productivity is generally higher in private land. This means that even though private tenure is located in areas of higher plant production, its evolution along the period under study is rather similar or significantly worse than the other tenure types, which in principle would be relatively handicapped. At this point we should also remind that the difference between desertification and temporal drought is the capacity of the environment to sustain plant growth once normal precipitation is reestablished (Riebeek, 2007). Therefore, a plausible conclusion would be that private land is recovering worse than other tenure types in some ZSNCs.

3. Cattle densities and desertification: One interesting feature of our result arises when comparing between open communal, illegally fenced lands pre-independence allocations in NKSW (all passing all tests in table 1). In this ZSNC, open communal tenure matches to the N#a-Jaqna and Nyae Nyae conservancies, where cattle densities are low due to regulated restrictions (see Gilolmo, 2014a: 62). On the other hand, illegally fenced land accounts for considerably higher cattle densities (as long as the illegal fencing is precisely erected to develop cattle farming), and the same applies to pre-independence allocations. Nevertheless, in NKSW, the trend of these tenure types are almost parallel. While illegally fenced and pre-independence allocations both show higher plant productivity (which is consistent with the fact that open communal is situated eastwards, the direction on which aridity increases towards the Kalahari margins), their slopes are very similar (see also table 2). This particularity could indicate that cattle densities may not be a paramount factor for plant productivity in the long run, or at least not just by itself.

CONCLUSIONS

In summary, our results add to the existing evidence that is seriously questioning the relation between communal tenure and environmental degradation (Ward et al., 1998; Bromley, 1990, 2008a; 2008b; Ellis & Swift, 1988). We offer strong evidence against the view of communal tenure as a cause a higher degree of land degradation and, thus, increasing the risk of desertification. Whether this conclusion can be generalized to the rest of Namibia, or used as a guideline for the African continent in general, is too risky to ascertain.

Future work should aim to confirm these results through the analysis of a longer time series, checking with high resolution imagery at selected critical sites and times. Also, coupled investigations of surface dynamics and management practices, with particular attention during drought periods, would be crucial to identify the processes that are causing the differences in trends.

However, the present results lead to critical questions about the foundations of the privatisation programmes that are currently being implemented in many dry African countries. This study offers an easily replicable methodology, which can be applied anywhere as long as the necessary data on land tenure and vegetation are available. The results offer enough confidence to suggest that, before the promotion of such programmes curbing communal land tenure, it is indispensable to inquire about the causal relation between communal tenure and land degradation more rigorously.

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