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Assessing the Drivers of Wetland Changes in Areas Associated with Wildlife-Based Tourism Activities in Zimbabwe

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Abstract

The study assesses wetland land cover changes associated with high wildlife densities and tourism activities in Dete vlei, located in Sikumi protected forest, adjacent to Hwange National Park, Zimbabwe. The vlei is used for photographic safaris and is associated with high number of tourists visiting the wetland to see a variety of wildlife species congregated in it. On-screen digitization and analysis of SPOT images for the period of 1984–2013 was used to determine land cover changes in the wetland. Field data were collected through observations, measurements and semi-structured interviews with key informants. The results of the study showed that the spatial extent of bare areas increased in the lower section of the vlei after the establishment of salt licks and watering points meant to attract many wild animals during the dry season. In contrast, wetland conditions have been expanding in the upper section of the wetland without artificial salt licks and watering points. Tourists' footpaths, road culverts, unplanned vehicles' roads, to mention a few, contribute to erosional features evident in the wetland. The study recommends the introduction of wildlife-based tourism management strategies in seasonal wetlands to minimise degradation and possibly loss of wetlands.

Keywords: land cover changes, wildlife population, photographic safaris, wetland ecosystem, tourism

1. Introduction

Wetlands cover 1.8% of Zimbabwe's total surface area [1]. The most common type of wetlands in Zimbabwe are vleis also known as dambos [2], described as seasonally waterlogged valleys

or depressions with herbaceous vegetation, mainly grasses and sedges, and devoid of trees [3]. About 60% of wetlands are found in communal and resettlement areas [1], and are predominantly used for cultivation and livestock grazing [4]. Several researches in Zimbabwe have been focusing on communal and resettlement areas to understand the impact of the aforementioned agricultural practices on various wetland ecosystem components such as vegetation, hydrology, geomorphology, soils and water quality [5, 6].

Estimates show that more than 50% of the original wetlands have been lost world over [7]. In Zimbabwe, estimates show that wetlands declined by almost 50% over the past three decades. In the 1980s, wetlands covered 3.6% of the total country area [3] compared to 1.8% in 2015 [1]. Despite previous research on severe wetland degradation in communal, resettlement and urban areas of Zimbabwe [2, 8], there is a dearth of information on how wetlands located in demarcated or state-protected forests (which accounts for part of 40% of wetlands in Zimbabwe) are affected by the existing land uses that are different to those of well-studied communal and resettlement areas, dominated by agriculture. Lack of information on wetlands condition may compromise effective management of these ecosystems in protected forest areas.

In Zimbabwe, demarcated forests are primarily established to manage catchment areas located on fragile Kalahari soils [9]. These forests are managed by a statutory body, the Forest Commission. The major focus of this statutory body is to ensure protection of the forests; hence, there is no deliberate policy to manage wetlands found in the demarcated forests. Wetland ecosystems in protected forests are managed as part of the forest ecosystem, with the primary objective being to protect the forest. However, these wetlands have different human threats to that of forests, a situation that may result in unnoticed wetland degradation and loss. Therefore, there is need to understand the ecological as well as the geomorphological conditions of wetlands in protected areas in light of the presence of potential degrading agents such as high number of tourists and wildlife densities. Some studies have shown that wetland degradation in game reserves is possible, although the rate and causes may vary spatially [10–13].

Dete vlei is primarily used for photographic safaris since it is adjacent to Zimbabwe's largest wildlife sanctuary, Hwange National Park. As a result, different wildlife species graze and drink water in the vlei during the dry season. Wetlands are known to provide forage for herbivores in the African savannah ecosystem over the dry season and during droughts [11, 14]. However, lack of wildlife management within the carrying capacity can lead to high grazing pressure and ultimately wetland degradation [11, 14, 15]. On the other hand, the population of wild herbivores may be threatened by widespread degradation of wetlands [11, 12]; hence need to explore ways of sustainably managing wetlands with different drivers of change.

Meanwhile, salt licks and watering points were established to attract wildlife for game viewing in Dete vlei. The importance of salt licks and watering points as attractants for game viewing has been studied [10, 16]. However, the link between wildlife-based tourism activities and wetland conditions has not been well studied in Zimbabwe regardless of the fact that wildlife pressure is known to have the most damaging outcomes to the world's natural environment, including wetlands [17]. This study, therefore, assesses the potential impact of wild animals

controlled by watering points and salt licks as well as the associated tourism activities on Dete vlei's cover during the dry season when more wildlife is attracted to the area. This study aims to provide baseline information that can be used to manage wetlands mainly used for wildlife-based tourism activities in protected areas.

2. Material and methods

2.1. Study area

Sikumi forest has several depressions, with Dete and Zingeni vleis forming the main drainage system of the forest. The study was carried out in Dete vlei found in Sikumi forest (27°10'E; 18°45'S), located in Hwange district of Zimbabwe (Figure 1). Sikumi forest is a demarcated forest area that occupies about 55,700 ha [18]. Dete vlei occupies about 903.1 ha, that is, approximately 1.6% of the total forest area. The forest shares boundaries with communal areas, large commercial farms and Hwange National Park (Figure 1).

Rainfall in the area is low, variable and unpredictable. The average rainfall for the past 5 years is 500 mm [9]. The rain season normally stretches from October to April. The average minimum

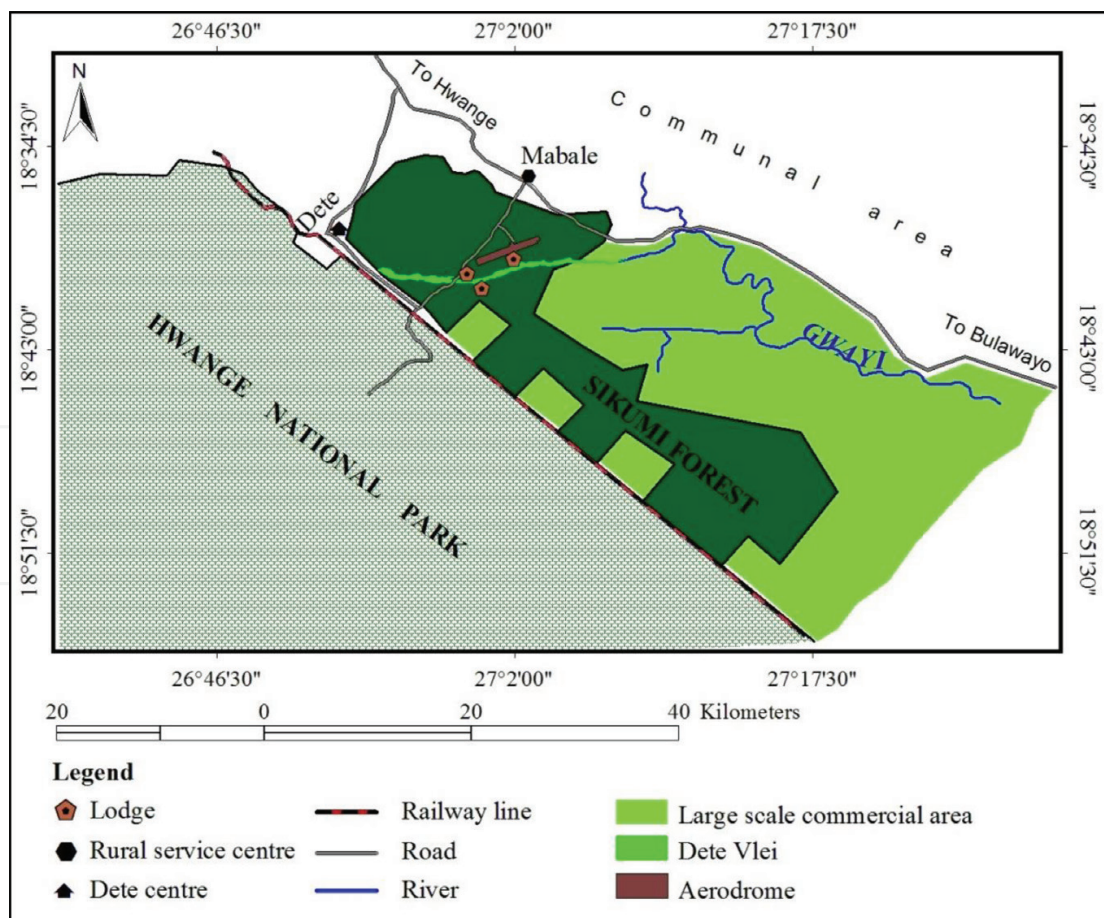


Figure 1. Map showing the location of Dete vlei in Sikumi Forest, Hwange district of Zimbabwe.

and maximum temperatures are 13 and 29°C, respectively, with occasional frost experienced in the depressions [9]. The forest reserve provides commercial timber and wildlife. The dominant soil type is the Kalahari sand associated with the endemic dominant *Baikiaea* genus tree species [18]. The depressions and gentle areas in the forest area are associated with pale sands.

The common grass species in the vlei are *Aristida*, *Sporobolus*, *Eragrostis*, *Pogonarrhia*, *Perotis* and *Hyperrhena* as well as sedges such as *Cyperus*. Due to the forest's proximity to Hwange National Park, the vlei has abundant and wide diversity of game. The common wildlife during the dry season includes elephants, buffaloes and different type of plains game. About 7500 ha of forest land, including the vlei, is leased to private operators for photographic safari business. Therefore, the vlei provides grazing and water to wildlife during the wet and dry seasons and at the same time sustains photographic safari activities. This means the impact of these wildlife-tourism-based business ventures on the vlei needs to be understood in order to come up with appropriate wetland use and management strategies as promoted by [19].

2.2. Hydrogeomorphic characteristics of the vlei

The study compares land cover changes in the upper and lower sections of Dete vlei. The lower section is primarily used for photographic safaris, whereas the upper section has been set aside for uncontrolled wild animal grazing. The whole vlei resembles the features of an unchanneled valley bottom [20]. The vlei has a gentle, longitudinal slope (approximately 1.5%), and no clearly defined stream. The wetland is located at the head waters of a stream that drains into Gwaai River. The predominant source of water for the vlei is direct precipitation, although subsurface inflows can be experienced from the protected forest area that occupies the entire upstream catchment area of the wetland due to the presence of dense vegetation and Kalahari sand soils with a high hydraulic conductivity and infiltration capacity. The use of the wetland for wildlife-based photographic safaris influenced by artificial watering points and salt licks has potential to change wetland cover and possibly degradation of the resource.

2.3. Wetland mapping procedures

Spatial and temporal changes of wetland ecological conditions in relation to erosion and vegetation cover changes were assessed by comparing SPOT satellite imagery for years 1984, 2007 and 2013 to determine the spatial extent of impact of various photographic safari activities. The upper section of the vlei has no artificial watering points and salt licks; hence was compared with the lower section characterised by watering points and salt licks established to influence game viewing. In this study, the upper section of the vlei, across the road to the western side (**Figure 2**), was used as a baseline condition to show an area grazed by wild animals without the influence of watering points and salt licks. Selection of the years for satellite imagery analysis was influenced by availability of high spatial resolution imagery. The image acquired in 1984 image was used as a baseline imagery since it pre-dates the establishment of artificial watering points and salt licks in the entire vlei. The areas that have no grass due to wildlife grazing, salt licking and watering points, which facilitate a high concentration of wild animals on the same spot more frequently, were digitised on screen and classified as bare areas. The spatial extent occupied by bare areas, water and grass within the vlei was

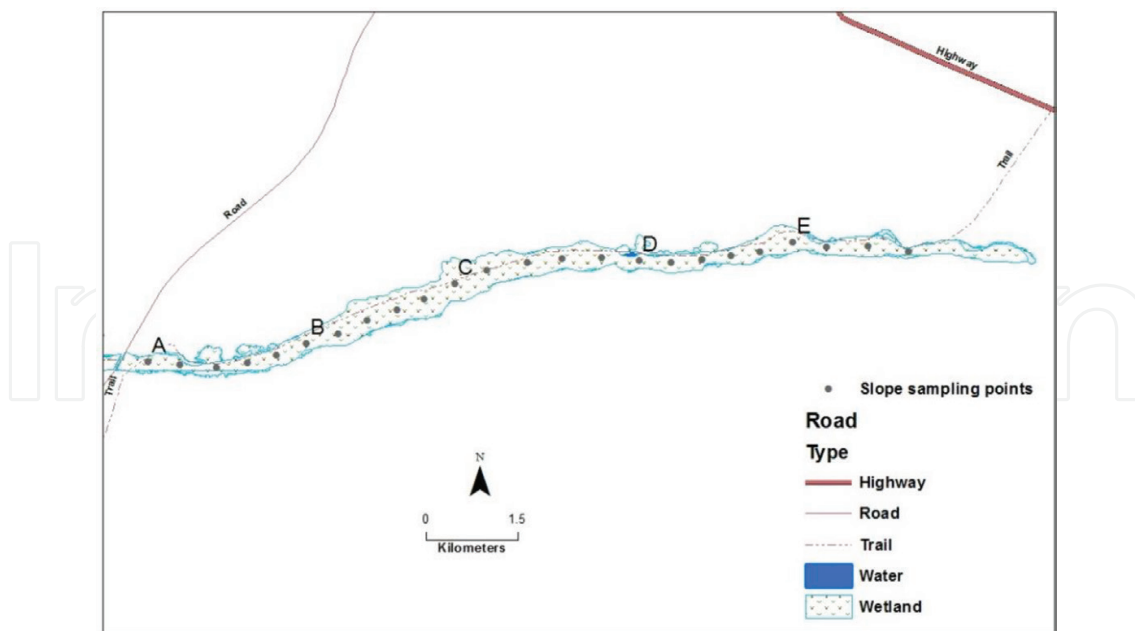


Figure 2. Slope sampling points on the lower section of the wetland.

computed in GIS environment. Image characteristics such as tone, texture, shape, colour and contextual traits as well as locations noted during the field surveys were used in characterising the land cover types within the vleis.

2.4. Field data collection methods

A field survey was carried out during the dry period between November and December 2016. Field observations were carried out to identify evidence of erosion in the form of rills and gullies, sediment deposition and grass cover loss within the vleis. The locations of these erosional sites were noted and used to facilitate their characterisation during the on-screen digitising procedure. Observations were further done, through transect walks, to ascertain if movement of wild animals and associated tourist activities was influencing vegetation cover changes and soil erosion within the vleis. Wildlife paths, pressure on grazing, gravel roads condition, salt licks and watering points were observed, noted and described.

The slopes of the vleis depression were measured at 500 m intervals, from the main road going eastwards (Figure 2; Table 1). The slope was measured since it influences water erosion, although the rate of erosivity depends on a combination of factors including rainfall amount and intensity, soil type, to mention a few [21]. The identified erosional features such as gullies' slope, depth, width and length were measured. Gully depth and width were measured using a tape measure, whereas the length was measured using a measuring wheel (Bosch GWM 32 Professional). Slope was measured and expressed in percentages.

The diameter and depth of the observed salt licks pits near watering points in different parts of the wetland were also measured to determine how the wetland morphology or landscape was altered by salt licking. Annual rainfall data (1962–2016) and annual mean daily minimum and maximum temperatures data (1962–2010) were obtained from the Meteorological

Point name	X coordinate	Y coordinate
A	26.98	-18.66
B	27.00	-18.66
C	27.02	-18.65
D	27.05	-18.64
E	27.07	-18.64

Table 1. Location of the selected slope sampling points.

Services Department of Zimbabwe. Local climate data were used to assess the possible effect of local climate variability on wetland vegetation condition and geomorphic processes such as erosion and deposition.

Historical information of the wetland's geomorphic condition was obtained from purposively sampled key informants targeted for semi-structured interviews. In this case, a template with open-ended questions was prepared to guide face-to-face discussions. The key informants were selected from organisations that are involved in photographic safari ventures, management of the forest areas located in the catchment area of the vlei or individuals who had knowledge of the area stretching over several decades. The key informants were the Safari Operators, former Forest Commission Divisional Manager for Indigenous Forests, Matabeleland North Forestry Commission Provincial Manager, Sikumi Forester and the Parks and Wildlife Management Authority Ecologist. Records of wildlife population changes and number of tourists were also obtained and reviewed.

2.5. Data analysis

Rainfall and temperature data obtained from the Meteorological Services Department of Zimbabwe used for determining trends were subjected to regression analysis performed in Microsoft Office Excel 2007. Trend analysis was done to determine if there was change in mean annual temperature (minimum and maximum) and annual rainfall totals, since temperature and rainfall amount influences vegetation cover and geomorphic processes such as erosion and deposition. Qualitative data generated through semi-structured interviews (on perceived changes in wildlife numbers, vlei's condition and climate trends) were analysed using thematic analysis method [22]. Wildlife population density was calculated basing on average game counts done by Forestry Commission in 2016 and the vlei size measured in ha.

3. Results

3.1. Local climate trends

Figures 3 and 4 show a graphical representation of annual rainfall totals and temperature. Generally, the vlei area experiences low rainfall and high temperatures. The average annual rainfall total is 544.38 mm. The total annual amount of rainfall has been decreasing between 1962 and

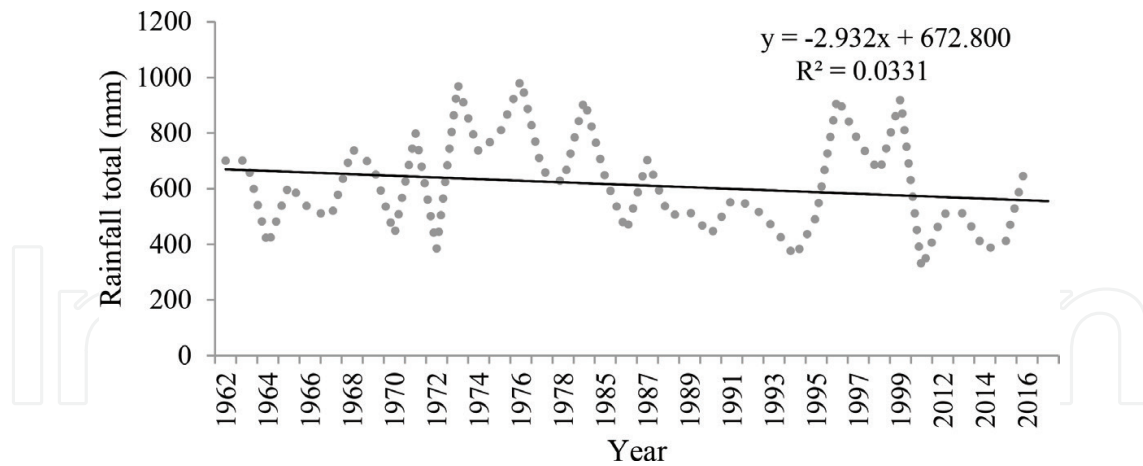


Figure 3. Annual rainfall totals for Dete Vlei, Hwange district (1962–2016).

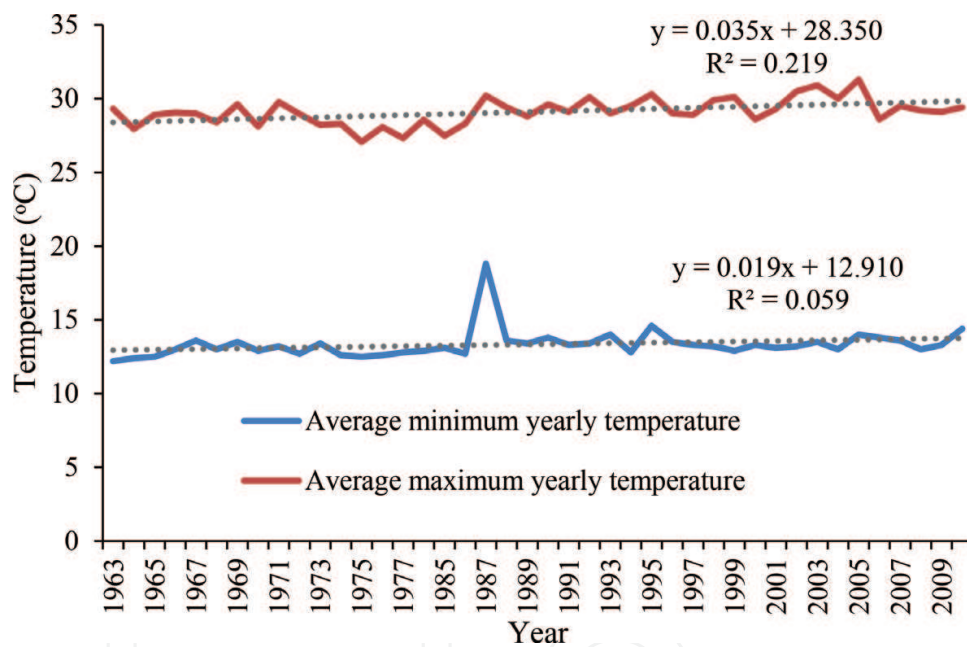


Figure 4. Annual minimum and maximum temperature for Dete Vlei, Hwange district.

2016 ($y = -2.932x + 672.800$; $r^2 = 0.033$). The highest (975.9 mm) and lowest (311.9 mm) amount of rainfall were received in 1973 and 2000, respectively. In contrast, mean maximum yearly temperature ($y = 0.035x + 28.350$; $r^2 = 0.219$) and the mean minimum yearly temperature ($y = 0.019x + 12.910$; $r^2 = 0.059$) have been increasing between 1962 and 2010. The mean maximum yearly temperature is 29.1°C, whereas the mean minimum yearly temperature is 13.3°C (Figure 4). The former Forest Commission Divisional Manager for Indigenous Forests attributes the reduction in rainfall to changing climate accompanied by frequent droughts that intensified from the year 2000.

3.2. Wildlife population changes

The common wildlife species found in the vlei are elephants, buffaloes, baboons, sables, impalas, kudu and warthogs (Figure 5). Generally, small and large predators account for relatively

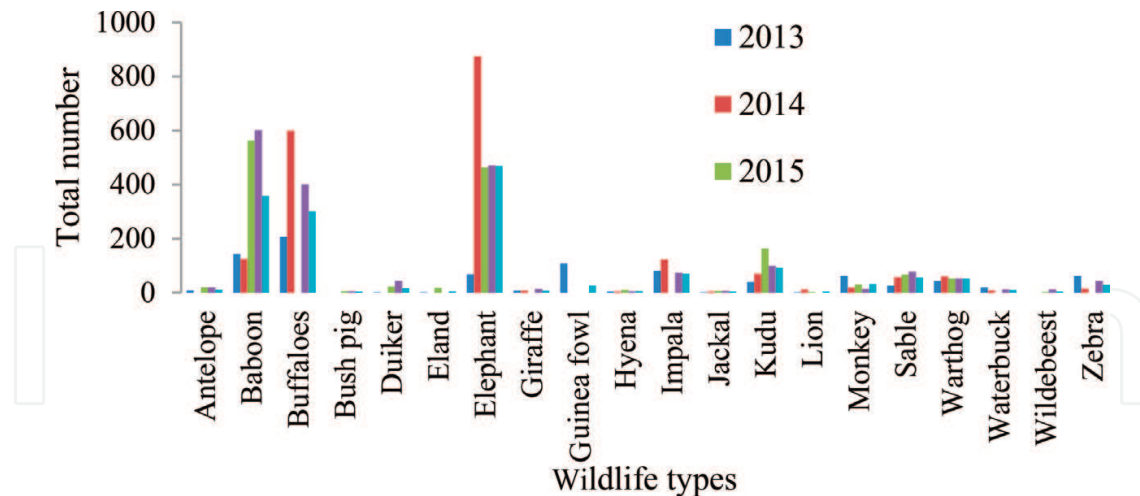


Figure 5. Wildlife species population between 2013 and 2016 (Source: Forestry Commission [9]).

few of the total number of animals found in the vleis as they are significantly outnumbered by herbivores, categorised as grazers, browsers or both. Large mammals such as elephants and buffaloes frequent the wetland for water and/or grazing. The elephant population is the highest, with an average of 469 over the last 4 years (2013–2016), whereas buffaloes have the second highest number of large mammals, with an average of 302.

Key informants indicate that plain game species such as impala, kudu, duiker, waterbuck and eland were also a common feature of the wetland landscape. Although game count statistics obtained from the Forestry Commission show that the population of different wildlife species has been fluctuating over the past years, in contrast, baboon populations have been increasing. The interviewed Ecologist and Forester indicated that the present wildlife population exceeds the carrying capacity of the area as evidenced by grazing pressure in some parts of the wetland. The elephants destroy trees on the edges/fringes of the wetland indicated by dominance of trimmed trees. The pressure on grazing has resulted in bare areas (Figure 6).

3.3. Wetland erosion linked to wildlife

Figure 6 shows that the wetland's lower section has erosional features such as developing gullies and is losing vegetation in areas surrounding artificial watering points and salt licks.

Spatio-temporal analysis of land cover shows that there is no bare area in the upper section of the vleis between 1984 and 2013. In contrast, the areas devoid of vegetation as a result of wildlife trampling and erosional features occupy 5% of the overall extent of the lower section of the vleis (Table 2). The bare area around artificial watering points and salt licks increased by 58.56% between years 2007 and 2013. They now cover 4.6% of the lower section of the vleis used for photographic safaris. Erosional features such as gullies, not present in the whole wetland during the previous years, occupied about 0.82 ha in the lower section of the wetland in 2013 (Figure 6; Table 2); a sign that geomorphological disturbances such as erosion were taking place. The overall spatial extent of the upper section of the wetland increased by 41.2%, whereas the lower section with artificial water points and salt licks shrunk by -2.3% between 1984 and 2013.

Year	Upper	Lower	Total vlei size	Bare area in the lower section of the vlei		Erosional features in the lower section of the vlei	
				Area (ha)	%	Area (ha)	%
1984	316	467.6	783.6	0	0	0	0
2007	348.8	429.7	778.5	13.32	3.1	0	0
2013	446.2	456.9	903.1	21.12	4.6	0.82	0.002

Table 2. Proportion of bare area (ha) and erosional features in the vlei.

Salt licks are evident in the lower section of the vlei and are characterised by several pits and areas devoid of vegetation (**Figure 7**). Other than pumped water, artificial salt licks appear to be attracting many different wildlife species during the dry season. This explains why high numbers of large mammals such as elephants, buffaloes and plains game are found in the lower section of the vlei throughout the year. This situation is in sharp contrast with the upper section of the vlei without salt licks where evidence of bare areas was not noted at all based on the SPOT satellite images (**Figure 6**). On average, salt licks of 3 m diameter and 35 cm depth are found in several parts of the lower wetland section. Field observation results showed that vegetation cover was completely lost in areas as wide as 800 m² around the salt licks (**Figure 7**). The deepest salt lick pit was 83 cm, whereas the widest pit was 8 m in diameter. Interviews with key informants revealed that some safari operators apply salt, especially in areas near the artificial water sources, in order to attract more wildlife for game viewing. Salt licking is assumed to have started in

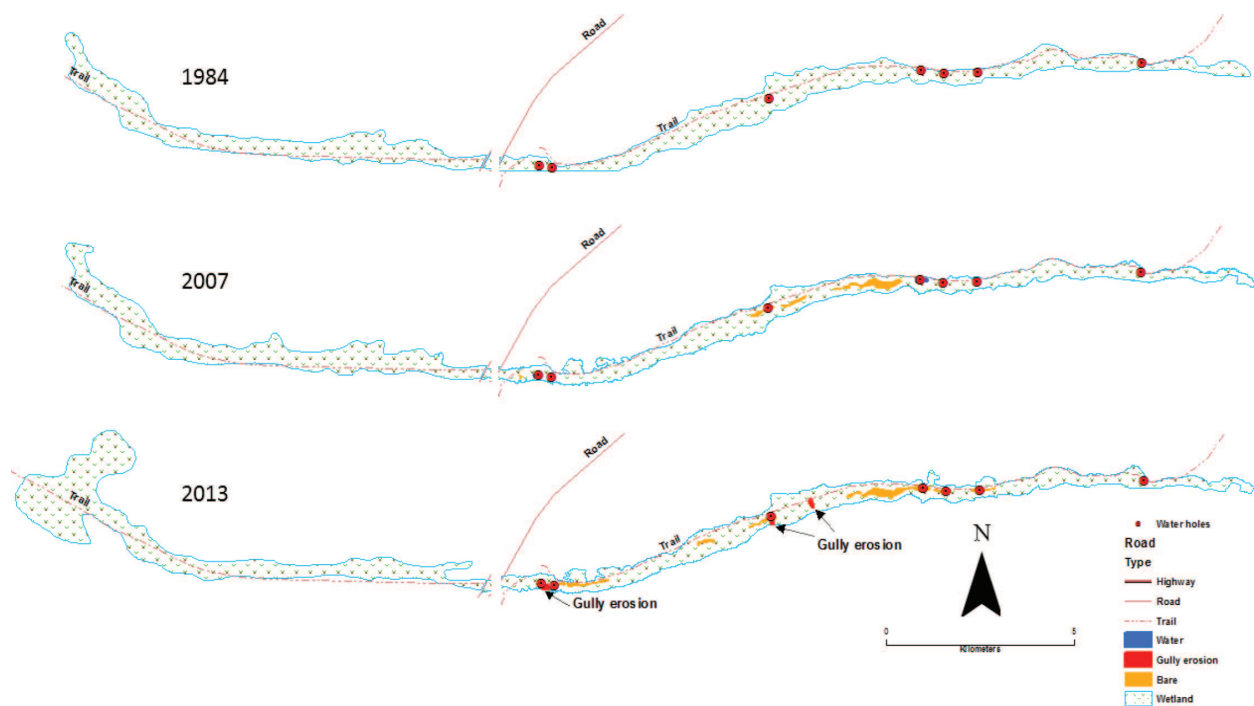


Figure 6. Suptio-temporal changes in erosional features and bare area linked to water holes in Dete vlei (1984–2013).



Figure 7. Section of the vlei altered by wildlife during salt licking.

the mid- to late 1990s in order to control the introduced Presidential Elephants, protected under a presidential decree of 1990 but instead the licks are attracting different wildlife species.

During the dry season when there is water shortage in the area, safari operators pump ground water from the wetland into open waterholes. These artificial watering points replenished by boreholes were established in the late-1980s across the lower section of the wetland, in proximity to lodges (**Figure 3**), to attract more wildlife for game viewing. Trampling is evident within 15 m around watering points as a result of large number of wild herbivores that drink water from these sources.

Due to high movement and frequency of wild animals in the vlei, mainly for water and salt licking, a number of wildlife trails or paths have been formed. Wild animals' trails are possibly facilitating the formation of several rills across the wetland area, especially in the lower section. The wildlife paths facilitate concentrated water flow, hence promoting soil erosion and siltation or sediment delivery into the wetland. Pressure on grazing by wild herbivores is a common phenomenon mainly around salt licks and watering points. Key informant interviewees attributed the grazing pressure to high wildlife populations and the presence of grazers around water points. This is more pronounced during the dry season due to physical water scarcity in the natural pans dotted around the forest area and in the adjacent Hwange national game park.

Meanwhile, elephants have been destroying trees, predominantly *Acacia* and *Terminalia* species along the edge of the wetland, forming a transitional zone between the vlei and the protected forest area. The elephant density is estimated at 0.01/km² in the whole Sikumi forest and 0.52/km² in the wetland area. This has affected vegetation density as exhibited by broken trees in the areas adjacent to watering points.

3.4. Soil erosion linked to tourist activities

Normally, tourists walk closer to wild animals at watering points to take pictures or films. The habituated elephants (by Allan Elliot since 1974) commonly found in the vlei area are

not vicious to humans. Given the fact that each of the lodges receives more than 200 visitors per fortnight during the dry season, some walking paths often used by tourists to get closer to the watering points are gradually developing into rills and gullies and there is evidence of deposition in the vlei as shown in **Figure 8**. Gully development seems to be further influenced by fairly steep gradient, which on average is 4% (**Table 3**). Point D with the steepest slope has a more pronounced gully.

Moreover, two weirs were excavated in the lower section of the wetland in the late 1980s to impound more water for photographic safari activities. Coincidentally, weir construction and boreholes drilling started at the same time when additional lodges were established. However, there is evidence of soil erosion on some of the weirs. Erosion is as a result of overtopping of the weirs during the rainy, especially during the years when high rainfall was received in the area. The eroded sediments are likely to increase sediment yield downstream, which may be severe if high rainfall persists, since rainfall in the area is highly variable (**Figure 8**).

There is a gravel road constructed along the vlei to facilitate easy game drive by tourists around the wetland area. The gravel road has drains which control and discharge runoff into the vlei at certain points. Channelized flow is discharged into the wetland resulting in gully erosion, especially where vehicles use unplanned drive ways to cross the vlei during the dry season. Unplanned drive ways in the vlei result in vegetation loss and defined channels



Figure 8. Gully development along tourists' foot paths.

Slope point	Slope angle
Point A	2.4
Point B	4.1
Point C	3.9
Point D	5
Point E	3.8
Average	3.8

Table 3. Slope gradient at selected interval along the vlei, in percentages.

for concentrated flow, a condition that enhances geomorphic process such as water erosion linked to surface runoff. The most pronounced developing gully is on average 3 m wide, 24 cm deep and 45 m long.

There are also unplanned roads that are used for game drive by tourists into the forest area surrounding the vleis. Some of the roads are developed following fairly steep gradients (on average 6% slopes) on the margins of forest area that forms the catchment area of the vleis into the wetland. Despite the fact that the predominant soil type is Kalahari sand (with high infiltration capacity), there is evidence of soil erosion on these roads as runoff is enhanced by the steep slope and channelized flow. Some of the sediment ultimately gets into the vleis, a situation likely to alter the ecological characteristics of the wetland due to enhanced sediment delivery.

4. Discussion

Results of this study indicated negative changes in the area occupied by the lower section of the wetland by a magnitude of 38 ha between 1984 and 2007 and by about 11 ha between 1984 and 2013. Meanwhile, the upper section incurred significant increase of about 32 ha between 1984 and 2007 and 130 ha between 1984 and 2013. The significant decreases in the area occupied by the lower section of the wetland could be attributed to the high concentrations of wild animals in the salt pans and water points as well as the high intensities of anthropogenic activities. On the other hand, the limited number of wildlife concentrations in the upper section could explain the intact and increases in the areal extent of the wetland covered by grass. Our results are supported by those of a study carried out in South Africa which also indicated that the creation of artificial water points in Kruger national park on the upland section of the park caused a high concentration of wild animals [23].

A gravel road stretching along the northern fringe of the vleis is likely to disrupt normal sediment mobility and deposition in the wetland area, a situation also observed by [23]. Erosion in the wetland is initiated from concentrated flow starting from culverts established to divert runoff from the road. This has resulted in rills and gullies in some parts of the lower wetland section where water is discharged into unplanned roads (**Figure 8**). Therefore, the effect of road construction through culverts on the vleis' erosion is evident. This result concurs with observations that roads tend to disrupt wetlands functioning through erosion and sedimentation [24].

Salt licking was observed as one of the main wildlife-related causes of wetland landscape alteration as indicated by existence of open pits surrounded by bare areas (**Figure 2**). This concurs with previous studies that salt lick areas are mostly devoid of vegetation as a result of heavy trampling from large herbivore which including those elephants and sables [10, 24]. This explains why in countries like Malaysia salt licks and land in its immediate vicinity are protected against disturbance of soil and vegetation [10]. Loss of vegetation cover generally exposes soil to erosion by either water or wind [25]. Despite the fact that the total amount of rainfall received

per season has been declining over the past four decades as shown by linear regression results ($y = -2.932x + 672.8$; $r^2 = 0.033$), the occasional high rainfall occurrences noted in this study could also be attributed to excessive erosion activities. Arid conditions worsened by increasing minimum and maximum temperature also may expose the bare areas around salt licks to wind erosion. Therefore, the wetland is susceptible to both water and wind erosion given the changing climate in the area. Wind speed in the vlei may be high since the depression is predominantly grassland surrounded by forests, which could make it a trough for wind passage.

Wildlife grazing is also influencing the alteration of the wetland's landscape. High grazing intensities by plain game species were mostly observed around watering points and were almost devoid of vegetation. The pressure on grazing has the potential to enhance soil erosion by exposing the soil facilitating surface runoff. Some previous studies revealed that the effect of cattle grazing around watering points is low [15] whereas that of wildlife was found to be high, characterised by absence of vegetation [10, 16, 17]. This explains why large-scale commercial farmers which occupied vleis in the early days limited the use of the vlei to late dry season grazing to avoid heavy grazing which resulted in erosion throughout the year [2]. In the case of the lower section of Dete vlei, pressure of wild grazing is high since grazing is continuous during the dry season while wild animals are attracted by watering points and salt licks to a central point. Therefore, strategies should be considered to regulate grazing around watering points and salt licks in order to mitigate soil erosion considering that bare conditions were not a common phenomenon in the upper section of the vlei which has no watering points and salt licks.

Wildlife trampling which is well pronounced within a 15 m radius of watering points also results in top soil loosening and loss of vegetation cover, making the soil susceptible to erosion and possibly siltation of the existing water points. This finding concurs with [10] who acknowledged that the visibility of wild herbivores trampling around watering points results in vegetation cover reduction. According to [13], the continuous trampling by wild animals in a forage land accelerates the reduction of vegetation cover and ultimately exposes the soil to erosion agents.

Wildlife vegetation destruction, especially *Acacia* trees by elephants, exposes soil to water erosion along the wetland fringes, facilitating increased sediment input into the wetland given its fairly steep gradient (**Table 2**). The effect of high elephant densities on vegetation and the environment in general is well documented [26]. This was complemented by findings by [27] that high elephant population results in severe environmental damage, loss of biodiversity and increased competition for scarce resources. In the case of Dete vlei, the elephant density is estimated at 0.01/km² in the whole of Sikumi forest (and 0.52/km² in the wetland area). According to the Ecologist and Forester, the current elephant population is beyond the optimum carrying capacity of the area. Considering that there are various wildlife species frequenting the vlei as well as a result of the presence of water during the dry season (**Figure 4**), the ecological carrying capacity of the vlei could have been severely exceeded as different wild animals compete for grazing; hence vegetation loss and the potential of soil erosion being accelerated in the vicinity of watering holes.

Furthermore, artificial salt licks attract more wildlife for photographic safaris, resulting in more tourists visiting the area at the detriment of the wetland. In this case, safari operators, by applying salt, are more concerned with the economic gains associated with the influx of game viewers at the expense of the vlei's ecological condition which is the basis for the existence of these economic activities. The tourists have also been contributing to soil erosion as evidenced by erosional features such as rills and gullies developing along footpaths around watering points in the lower section of the wetland. Therefore, instead of simultaneously harmonising environmental and economic considerations to achieve wise use of the wetland, these two objectives are treated as discrete entities by safari operators, a situation with potential to cause vlei degradation and loss and ultimately loss of business in the long run for the safari operators.

Unplanned and poorly designed drive ways have potential to worsen the rate of erosion despite the reduction in rainfall amounts received in the area. This is more evident where some roads from the catchment surrounding the vlei were established following fairly steep gradients, a situation likely to accelerate the rate of soil erosion due to the effect of concentrated flow and possibly increased sediment yield. This may suggest that vehicle movements if not well planned and monitored have great potential to cause soil erosion in the wetland and tourist areas.

Although the gullies noted in this study are relatively small (a depth of 24 cm) when compared with those reported in other studies [2] which exceed 50 cm in depth, they are still of major concern. This implies that intervention strategies to mitigate soil erosion should be considered so that the vlei does not develop big gullies as those noted by Whitlow in the communal areas of Zimbabwe. These gullies are a growing threat to the socio-economic benefits linked to wetland utilisation. This is grounded on the findings of this study which illustrated that there is a temporal increase in the spatial extent of bare areas in the lower section of the wetland and overall reduction in the wetland size. In contrast, the upper section of the wetland without watering points and salt licks is increasing in size (**Table 1**). This suggests that if photographic safari activities, watering points and salt licks, in particular, are not well regulated, degradation of the wetland is likely to be more pronounced.

5. Conclusions

The study assessed wetland land cover changes associated with high wildlife densities and tourism activities, using Dete vlei in Hwange district as a case study. Results show that bare conditions have been increasing around watering points and salt licks resulting in the reduction in wetland conditions of the lower section. In contrast, the upper section remains without bare cover and the wetland conditions are expanding. Based on these findings, we conclude that photographic safari activities such as wild animals grazing and trampling around artificial salt licks and watering points, vehicle movements and tourists paths are contributing to vegetation loss and erosional features. Therefore, there is need for deliberate policy and strategy to control wetland degradation in protected used for photographic safaris. The strategy should involve all stakeholders (private players and public institutions) in order to achieve sustainable wetland-based photographic safari business.

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Conflict of interest

No conflict to declare.

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