International Journal of Ecology and Environmental Sciences 45 (2): 123-136, 2019
ISSN: 2320-5199 (Online)

Consequences of Land-Use/Land-Cover Dynamics on Range Shift of Cape Buffalo in Western Ethiopia

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ABSTRACT

Land-use/land-cover change has significant negative impact on the distribution, range reduction, migratory routes, species-habitat interactions and wildlife habitats. Hence, understanding the impact of land-use/land-cover change on wildlife and their habitats is highly crucial to design appropriate remedial action for sustainable conservation of wildlife. In the present study, Landsat 5 TM, Landsat 7 ETM$^+$ and Landsat 8 OLI (1986, 2001 and 2017) satellite imageries were used to examine land-use/land cover dynamics of the middle Didessa-Dabena Valleys and Jorgo-Wato Protected Forest, and its impact on the distribution and range shift of Cape Buffaloes (Syncerus caffer Sparrman, 1779). In addition, local people's view about the likely impact of human on the distribution of buffaloes was collected through questionnaire in the forms of interview. This study revealed that forest and farmland habitats have increased, whereas savanna woodland and shrubland have decreased during 1986–2017. Shrubland, forest and savanna woodland habitats were the three possible habitat types of Cape buffalo that had converted to farmland by 33%, 25% and 19%, respectively, during 1986-2017. Besides, high human population (84.5%), agricultural land expansion (81.2%) and bushmeat hunting (50.7%) were the top three factors that affect wildlife and their former habitats in the Didessa-Dabena Valleys. The synergistic interactions of land-use/land-cover change and severe human induced pressure such as poaching, formal and informal resettlement programmes had caused the contraction of former ranges, localized distribution and partial ranges shift of Cape buffaloes to Jorgo-Wato Protected Forest where buffaloes have not been recorded before. For sustainable conservation of Cape buffaloes in Jorgo-Wato and Didessa-Dabena River Valleys, a corridor should be designed to increase gene flow between the two populations. Moreover, the implementation of resettlement programmes in the potential wildlife habitats should consider a balance between wildlife conservation and public interest through the involvement of professionals from different sectors.

Key Words: Didessa-Dabena Valley; Historical Range; Jorgo-Wato; Resettlement; Migration

INTRODUCTION

The Didessa-Dabena River Valleys and Jorgo-Wato Protected Forest have been among the known wildlife-rich areas in the western parts of Ethiopia.However, currently, these areas are partially invaded by humans for residential, agriculture and livestock ranching. Despite the severe human pressure on the wildlife of the region, studies of wildlife and their habitats have been negligible. In Ethiopia, areas that are home to vulnerable, threatened, endangered and endemic species have been explored, whereas the remaining areas obtained less attention. Moreover, least concerned large-bodied species such as African buffaloes (or Cape buffalo; *Syncerus caffer* Sparrman, 1779) have less room for studies and which will gradually qualify them for vulnerable or threatened species categories unless adequate conservation effort is given.

Didessa-Dabena River Valleys have been known to host large mammals such as African buffalo, elephants, lion, bushbuck, rhinoceroses, African wild dog, warthog, bush pig, giant forest hog, several other primates,

herbivores and carnivores (Dunlop 1937, Seltzer 1993). As a result, parts of the valley have been designated as "Didessa Wildlife Sanctuary" during the Derg regime, the former ruling party of Ethiopia. However, since the last three decades, the impacts of human and land use dynamics of wildlife becomes more severe than ever. This resulted in the extirpation of elephants, reedbuck, rhinoceroses, and African wild dog or partial displacement of African buffaloes into JWPF. Jorgo-Wato Protected Forest is an extension of DDRVs, located on the western escarpments, separated by some fragmented corridors. However, African buffaloes has not been not known as inhabitants of JWPF and dense forests shifting from grassland or savanna woodland habitats. Jorgo-Wato Protected Forest has been known as a reservouir of large mammals displaced from DDRVs. African buffaloes and lions have been known to make sporadic movements between the two areas. However, the bilateral movement of large mammals gradually declined as humans encroached along the corridor. Cape buffaloes remained and survived in JWPF, whereas lions were removed through hunting due to human–lion conflicts over livestock depredation. Therefore, investigation of the likely causes for the partial range shift of Cape buffaloes from savanna woodland to montane forest habitats would be an excellent input for future conservation of large mammals, their habitats and associated human–buffalo conflicts in the area.

Didessa-Dabena River Valleys have been known to host an abundant number of African buffalo population since historic time (Dunlop 1937, Seltzer 1993). However, their distributions have been drastically reduced since 1991, since the fall of the Derg regime. The main causes for the range collapse of buffaloes were hypothesized to be increased human population, accompanied by poaching (for bushmeat and trophy), habitat loss and fragmentation. Large mammals such as African buffaloes are highly mobile in response to human induced environmental changes and seasonal resource variations (Lindsey et al. 2007). Changes in environmental conditions usually increase the movement of African buffaloes to more suitable areas (Ryan et al. 2006). Hence, the historical distribution of a species is important to know the extent of a species distribution range and to evaluate the extent of range reduction in the area (Rookmaaker and Antoine 2012). In most protected areas, however, information about the past and current distribution pattern of species, migratory corridors and the causes of species range shift are negligible (Ehrlich 1996). In this study, an effort was made to reconstruct the former buffalo ranges, and locate the current ranges in the middle Didessa-Dabena River Valleys and Jorgo-Wato Protected Forest. Reconstructing the distribution ranges of species through time is used to improve future conservation perspectives and strategies for the species (Turvey et al.2015).

Species distribution data have significant impacts on the ecology and conservation of animals (Lomolino and Channell1995). Animal distribution data are used to identify the species presence or absence and to determine the principles of translocation and restoration of species from which they have been extirpated (Kerley et al. 2003). Moreover, past distribution data are used for effective landscape-level conservation of larger mammals (Boshoff et al. 2001), describe range contractions or expansions (Laliberte and Ripple 2004) and change in the patterns of distribution of the species (Courtois et al. 2003).The spatial and temporal distribution of species are affected by the synergistic interactions of multiple factors (Thomson et al. 1996). Biotic factors (e.g. forage quality and quantity) (Redfern et al. 2003) and water (Bailey et al. 1996) play a primary role in the distribution of ungulates. Distribution of species is also associated with habitat selection, species interactions, resource variations and anthropogenic pressure (Thomson et al. 1996). Agricultural land expansion, forest clearance and over-grazing are the main anthropogenic activities that affect species distribution (Meyer 1995, Marzluff and Ewing 2001, Schmiegelow and Monkkonen 2002) by modifying the environment in a way that alters species interactions, distribution and diversity (Kurki et al. 1998, Kiesecker et al. 2001).

Anthropogenic activities are responsible for land–use/land–cover (LU/LC) changes (Sisay Nune et al. 2016). It is the cause for the loss of wildlife habitats (Skole et al. 1994) and blockage of wildlife corridors (Gordon 2009). Land–use/land–cover change is the modification of the physical state of various land cover types by humans(Ellis 2006).It was primarily caused by the expansion of agricultural land and settlements (Botkin and Keller 2010) around protected areas, which were directly associated with habitat loss, fragmentation and loss of wildlife (Gordon 2009). As described by Okello et al. (2011), encroachment of people in Amboseli, Kenya, resulted in wildlife loss, range contractions and obstructions of wildlife corridors. The reduction of wildlife at global, regional and local level is linked to LU/LC changes, which are accompanied by encroachments and diverse anthropogenic activities (Loibooki et al. 2002). Understanding the impacts of

LU/LC changes on the distribution, range shift and range contraction of buffaloes in DDRVs are crucial to design future conservation plan onthe land–use systems over wildlife ranges in the area. To realize this, LU/LC changes of the past 32 years of the ranges of African buffaloes were used to describe the impacts that LU/LC changes posed on the distribution, range collapse and partial range shift of Cape buffaloes from the savanna woodland habitat of Didessa-Dabena River Valleys to Jorgo-Wato montane forest.

THE STUDY AREA

Didessa-Dabena River Valleys (DDRV) and Jorgo-Wato Protected Forest (JWPF) are located in Oromia Regional State, west of Addis Ababa (Figure1). Didessa river is the largest tributary of the Blue Nile in terms of volume of water. It rises at Mt. Vennio and Mt. Wache ranges which are located in the South Western part of Ethiopia (Sima 2011). Didessa-Dabena river valleys are mainly characterized by open woodlands of *Combretum, Commiphora* and *Acacia* species mixed with *Hyparrhenia* species. In addition, vast areas of the valleys are covered by bamboo forest mixed with *Hyparrhenia* species. It is characterized by low land climatic condition. The maximum and minimum temperature of Didessa-Dabena River Valleys was 36.5 ^{O}C and 16.8 ^{O}C, respectively. The altitude ranges from 1400 m at the valley floor to 1900 m at the escarpment (Jemal and Hugh-Jones 1995). During the Derg regime, parts of Didessa-Dabena River Valleys was designated as “Didessa Wildlife Sanctuary” which is currently called “Haro Abba Diko Controlled Hunting Area”. Though Didessa-Dabena River Valleys possess potential wildlife areas, Haro Abba Diko Controlled Hunting Area covers only about 200 km^2.

Jorgo-Wato Protected Forest is located on the western escarpments of Didessa-Dabena River Valleys separated by fragmented corridor. It mostly comprises natural and plantation forests with broad leaved evergreen trees of over 30 m high. Unlike Didessa-Dabena River Valleys, Jorgo-Wato Protected Forest experiences subtropical climatic condition. The maximum temperature of Jorgo-Wato Protected Forest was 28^{o}C in February and March, but the minimum was12^{o}C in July and August. The mean annual rainfall of Didessa-Dabena sub-basin ranges between 1509 mm to 2322 mm in the northern catchments (Sima 2011). The

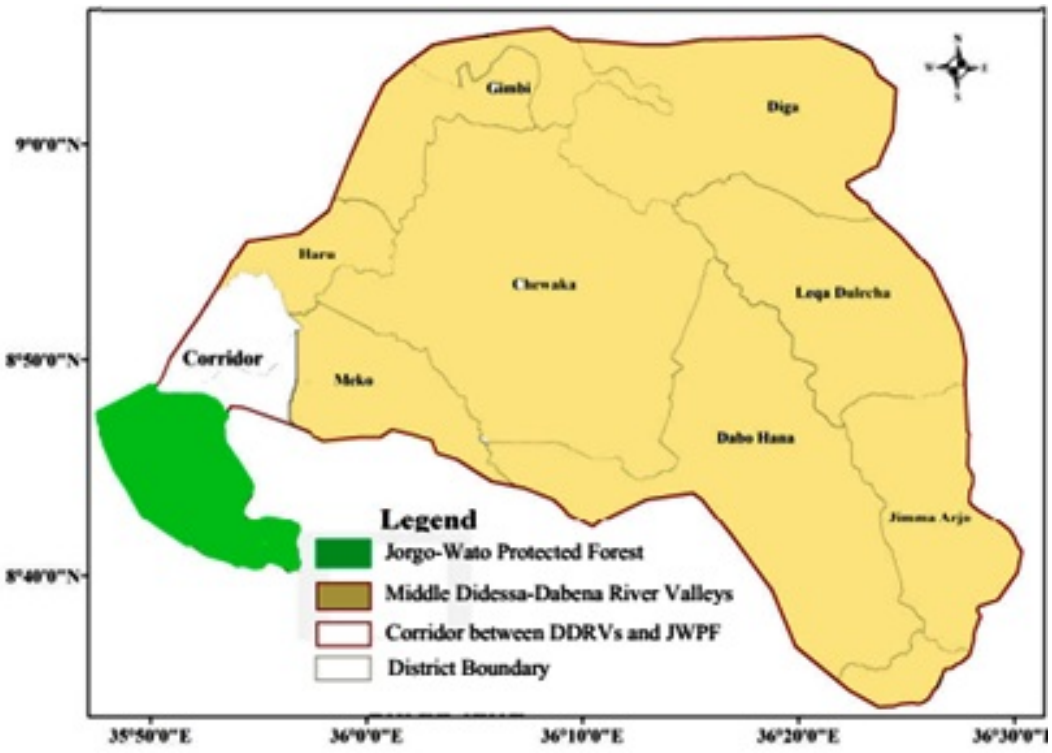

Figure 1. Map of Didessa-Dabena River Valleys and Jorgo-Wato Protected Forest

area generally receives heavy rainfall during the wet season and decreases during the dry season.Both areas harbour diverse arrays of medium and large sized mammals confirmed through community information, infrared camera traps, and direct and indirect evidences. Some of the large mammals include: *Syncerus caffer* Sparrman,1779, *Cercopithecus mitis* Wolf, 1822, *Tragelaphus scriptus* Pallas, 1766, *Sylvica pragrimmia* Linnaeus, 1758, *Crocuta crocuta* Erxleben,1777, *Canis aureus* Linnaeus, 1758, *Potamochoerus larvatus* F. Cuvier, 1822, *Hylochoerus meinertzhageni* Thomas, 1904, *Orycteropus afer* Pallas, 1766, *Papio anubis* Lesson, 1827, *Colobus guereza* Ruppell, 1835, *Phacochoerus africanus* Gmelin, 1788, *Civettictis civetta* Schreber, 1776, *Panthera pardus* Linnaeus, 1758 and *Felis caracal* Schreber, 1776.

METHODS

Historical and Current Buffalo Ranges

The former buffalo ranges were collected from historical records (Boshoff and Kerley 2010), informal interviews with the former illegal poachers (Goodman and Tomkinson 1987) and elders who have been living in the area for long periods. Respondents were asked to orally narrate the distribution timeline of buffalo ranges by naming particular areas where buffaloes survived in the past (Boshoff and Kerley 2010). Furthermore, distribution areas were recorded during actual field visits and geo-referenced using ArcGIS. The current distributions of buffaloes were recorded based on direct and indirect evidences and community information. Information about the time buffaloes invade JWPF was determined through interviews with retired and active wardens and focus group discussion with elders who have been living around JWPF throughout their life. Accordingly, approximate locations of the former and current ranges of African buffaloes were marked on the map as described by Lehman (2004) and Ali et al. (2009) using ArcGIS. The hypothetical migration routes of buffaloes from DDRVs to JWPF were also marked on geo-referenced map of the area.

Image Acquisition, Processing and Analysis of Land Cover Classes

To analyse LU/LC changes of the years 1986, 2001 and 2017, Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM^+) and Landsat 8 Operational Land Imager (OLI) imagery were used (Table 1). These images were obtained from the Global Land Cover Facility (GLCF) through Earth Science Data Interface (ESDI) and from the United States Geological Survey (USGS)earth explorer. Each image has a ground resolution of 30 m. Images of the above mentioned three years were obtained during the dry season to get clear images of land cover types to make the analysis easier and precise. Satellite images were processed and analysed using Environment for Visualizing Images (ENVI) 5.3 software and land cover–maps were made using ArcGIS version 10.4.1. Image processing and analysis were done through image cleaning, compositing, masking, clipping and radiometric and geometric corrections (Campbell and Wynne 2011).

Table 1. Characteristics of satellite data used for LU/LC change analysis

Year	Sensor	Acquisition season	Resolution	Row/path	Sources
1986	TM	February	30 m	54/170	USGS
2001	ETM+	February	30 m	54/170	GLCF
2017	OLI	March	30 m	54/170	USGS

In the present study, five major land-use/ land-cover classes, namely: forest, savanna woodland, bare land, farmland and shrubland were identified by associating pixel on the satellite image with ground truth information (Table 2). A total of 110 ground truth points was recorded using Garmin 12 GPS for the maximum likelihood classifier technique. Vegetation types were recorded and their land–cover classes were verified by photographs taken during the field work. Ground truth points were used as training sites for each land–cover class. These training areas were used to ensure the accuracy of supervised classification and interpretation of the results. Supervised classifications of all images were carried out using the maximum likelihood classifier technique (Hord 1982). Images of the three years were compared to describe land-cover changes in three phases, 1986–2001, 2001–2017 and 1986–2017. Classified images were compared using the post classification image comparison technique (Singh 1989). The accuracy of classified images was assessed using a confusion matrix. Accordingly, the overall accuracies for the years

Table 2. Descriptions of land–use/ land–cover types in the area

LU/LC types	Descriptions
Forest	Areas covered by natural and planation forests, riverine and riparian vegetation. It also includes coffee plantations in the forested habitats.
Savanna woodland	Contains Combretum, Commiphoraand Acacia species mixed with dominantly grown Hyparrhenia species
Farmland	It includes croplands, human settlements and fallowlands of not more than one year
Bare land	Includes herbs and small grasses that left the soil exposed when burned or grazed. It also includes rocky grounds and highly degraded fallow agricultural lands of more than two years.
Shrubland	Includes savanna grasslands mixed with shrubs, bamboo and a few scattered trees

1986, 2001 and 2017 were 85.3%, 89.4%, 94.2%, with a Kappa coefficient of 0.871, 0.891, 0.917, respectively. Change statistics were computed by comparing the image values of two periods. The overall change per class of each period revealed positive values for an increase and negative values for decrease of classes.

Respondents View of Human Impacts on Buffaloes

People's view about the likely impacts of human on the distribution of buffaloes and local extirpation of large mammals was collected from four districts (Dabo Hana, Meko, Chewaka and Belo Jeganfoy) that share vital buffalo ranges in the DDRVs. Residents of these districts were selected because they were assumed to have enough knowledge and exposure to the status of buffalo's range as they have been living in the area. Questionnaires in the forms of interview were used to collect information from a total of 207 adult individuals of four districts. The perception of respondents was coupled with the results of LU/LC changes to infer about the probable causes of the buffalo range collapse, localized distribution and partial migration into JWPF. The time and how buffaloes colonized JWPF, and informal interviews were not incorporated into systematic analyses, but discussed qualitatively. Land–use/ land–cover changes were analysed using descriptive statistics for the years 1986, 2001 and 2017 to show the variation between each of these years. The differences between respondent's opinion about the causes of buffaloes range collapse were analysed descriptively and by the chi-square test between districts.

RESULTS

Historical and Current Buffalo Ranges

Historically, African buffaloes have been known to exist widely in the whole lowland parts of DDRVs bordered by the highland escarpments. As described by residents of the DDRVs, the distributions of buffaloes have been common in the area until 1990s. During the Derg regime, parts of DDRVs were designated as "Didessa Wildlife Sanctuary" which is currently called "Haro Abba Diko Controlled Hunting Area". The former ranges of African buffaloes have been gradually shrunken since the transitional government of Ethiopia. Currently, buffalo ranges were localized to few potential and core areas of DDRVs, which includes along Dabena River bank, Haro Abba Diko Controlled Hunting Area (Dabo Hana district), Qoddi Gassi (Meko district) and Gara Samen (Chewaka district) (Figure 2). However, African buffaloes were less likely to survive along the middle Didessa River bank and the surrounding areas.

The survival of African buffaloes has not been known historically in JWPF. As mentioned by retired and active wardens and group discussants, Cape buffaloes colonized JWPF between 1994 to 1998 from the nearby buffalo–rich areas of DDRVs called Qoddi Gassi. Respondents hypothesized that the buffaloes had two main routes to colonize JWPF. The first route follows the Dardara mineral water, which originates from the base of JWPF and flows down to DDRVs. Hence, buffaloes have been assumed to track the courses of this mineral water as of Qoddi Gassi and surrounding areas through Homa Chalte, Siba Badosi and Dardara mineral water to the northern parts of JWPF. The second route has been associated with small to large mountain

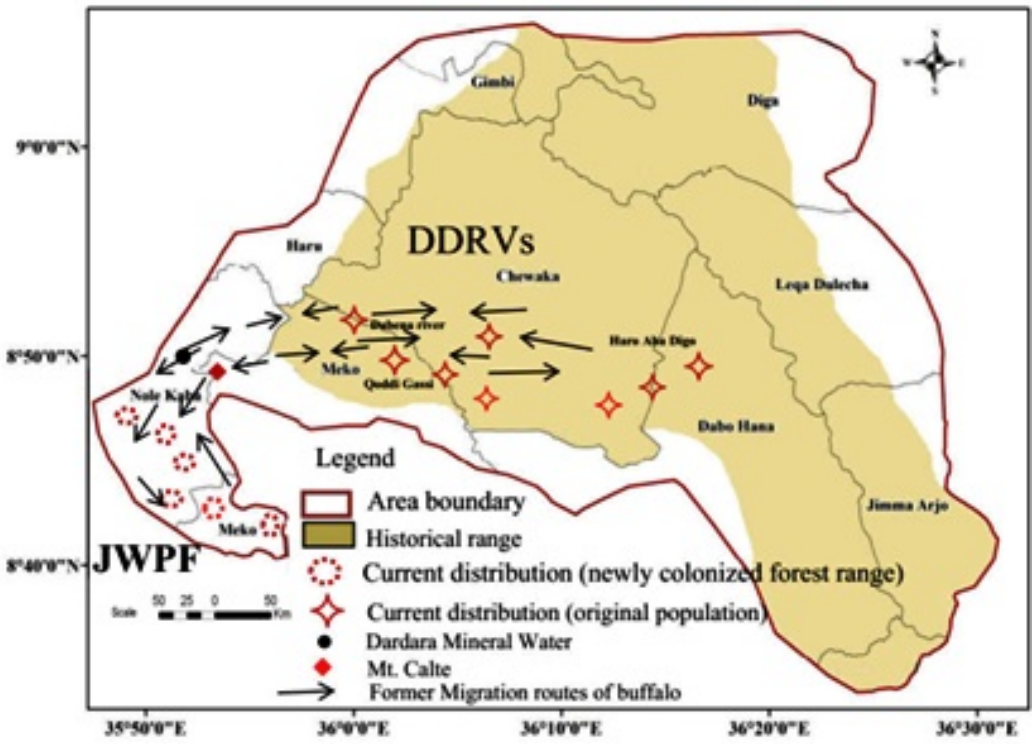

Figure 2. Historical and current distributions of Cape buffaloes and their hypothetical migration routes between Didessa Dabena River Valleys and Jorgo-Wato Protected Forest.

chains, steep slopes and valleys between JWPF and DDRV areas. This route started from Qoddi Gassi areas through Homa Chalte, Mount Chalte and Mount Jallo to the northeastern parts of JWPF. This route is characterized by steep slopes and rocky hills which is mostly used for coffee plantation rather than crop farming. These two routes have been known to serve for the bidirectional movement of buffaloes between DDRVs and JWPF. Recently, buffaloes were killed by residents along the second route while they fled to join JWPF.

Land-Use/Land Cover Class Analysis

In the middle DDRVs, savanna woodland was the dominant land cover types in 1986, followed by shrubland and forest, whereas bare land represented the least. However, by 2001, the extent of savanna woodland was reduced, and shrubland formed the largest area cover, followed by savanna woodland and farmland. In the year 2017, shrubland also occupied the largest part of the area, followed by forest and farmland (Table 3). The bare land represented the smallest extent of the area during all the study years.

Table 3. Land–use/land–cover types (km^2) of the middle Didessa Dabena River Valleys and Jorgo-Wato Protected Forest as determined from satellite images of 1986, 2001 and 2017

LU/LC types	1986		2001		2017	
	km^2	(%)	km^2	(%)	km^2	(%)
Forest	371.7	14.4	315.8	12.2	725.1	28.0
Savanna woodland	980.5	37.9	728.6	28.2	278.9	10.8
Farmland	313.2	12.1	483.1	18.7	695.1	26.9
Bare land	30.3	1.2	267.8	10.3	77.4	3.0
Shrubland	892.3	34.5	792.9	30.6	811.4	31.4
Total	2588	100	2588	100	2588	100

Land–use/land–cover map of the middle Didessa-Dabena River Valleys during the years 1986 - 2017 are presented in Figure 3.

Land–use/land–cover changes of the middle DDRVs to JWPF showed a remarkable land transformation in which each cover types experienced losses

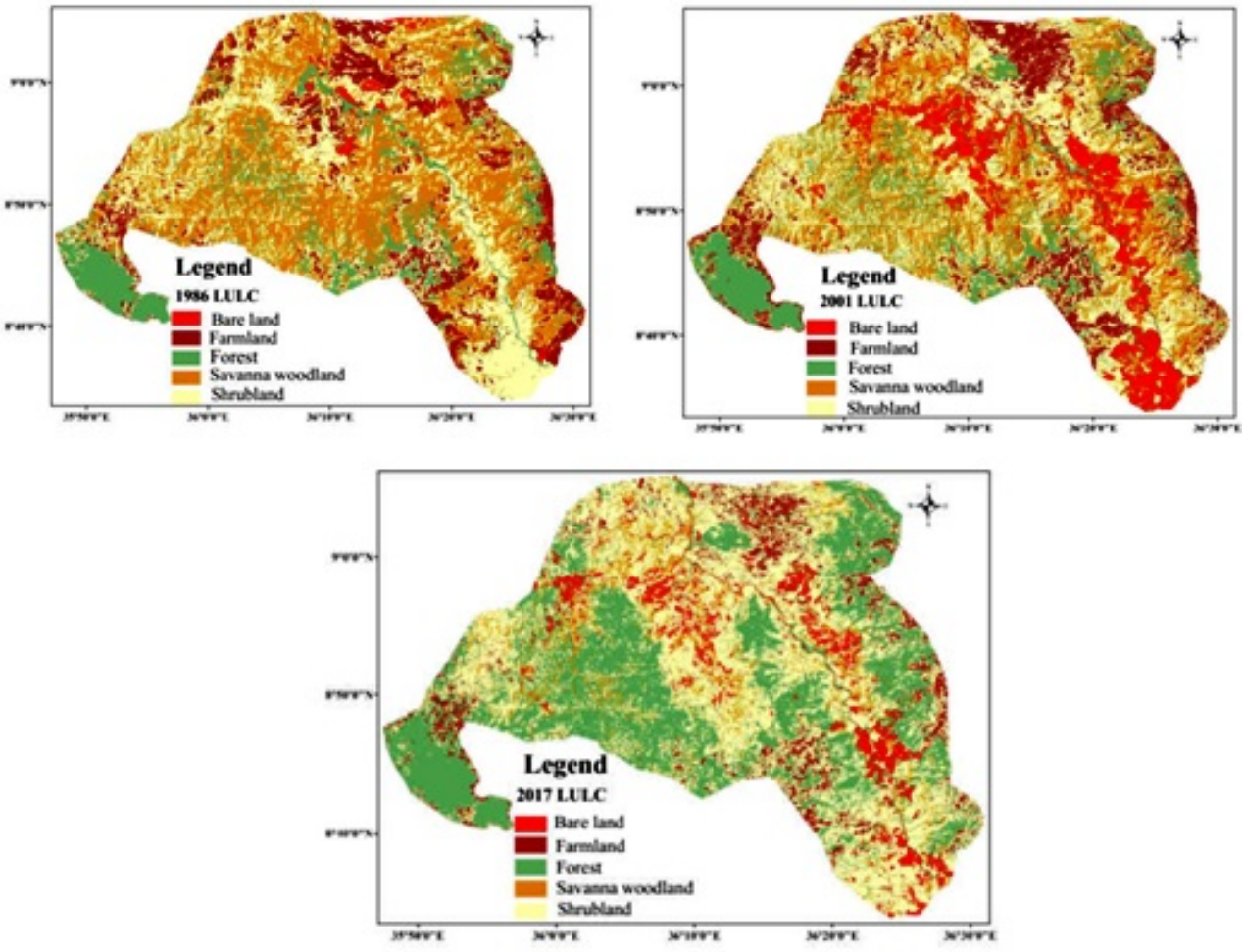

Figure 3. Land–use land–cover types of the middle Didessa Dabena River Valleys and JWPF in the years 1986, 2001 and 2017.

in one period and gains in other periods in the area. Human intervention mainly transformed savanna woodland and shrubland into different cover types. Forest cover decreased from 14% in the year 1986 to 12% in 2001, but showed a remarkable increase by 16% during 2001–2017. Savanna woodland showed a consistent and tremendous decrease from 38% coverage in 1986 to 28% and 11% in the year 2001 and 2017, respectively. To the contrary, there was a consistent increase in the extent of farmland from 12% in the year 1986 to 19% and 27% in the year 2001 and 2017, respectively. Shrubland was reduced by 4% between the years 1986-2001, increased only by 0.7 during 2001-2017, but was reduced by about 3% during 1986–2017. Forest cover increased by 14%, farmland increased by 15%, whereas savanna woodland vegetation decreased by 27% over the 32 years of the study period (1986–2017) (Table 4).

Table 4. Land–use/land–cover changes (km^2) of the middle Didessa Dabena River Valleys to JWPF as determined from satellite images of 1986, 2001 and 2017.

LULC types	1986–2001		2001–2017		1986–2017	
	km^2	%	km^2	%	km^2	%
Forest	-55.9	-2.2	409.3	15.8	353.4	13.6
Savanna woodland	-251.9	-9.7	-449.7	-17.4	-701.6	-27.1
Farmland	169.9	6.6	212.0	8.2	381.9	14.6
Bare land	237.5	9.2	-190.2	-7.3	47.3	1.8
Shrubland	-99.4	-3.8	18.5	0.7	-80.9	-3.1

Shrubland, savanna woodland and forest habitats were preferably utilized by buffaloes than the other land–cover types. Hence, LU/LC changes related to

these cover types were assumed to have negatively influenced many behavioural activities of buffaloes. The trends of the three possible buffalo habitats converted to farmland are indicated in Figure 4. Shrubland was the first land cover type that constantly contributed large areas to be converted to farmland, followed by savanna woodland and forest during the three time periods (1986-2001, 2001–2017 and 1986–2017). Savanna woodland was a cover type that loses much of its size during this period. Shrubland contributed the largest area converted to farmland, followed by savanna woodland and forest cover types. The percentages of shrubland converted to farmland were 11%, 21% and 33% between the time periods 1986–2001, 2001–2017 and 1986–2017, respectively. The percentage of savanna woodland converted to farmland was about 3% between 1986 to 2001, but increased consistently to 12 % and 19% between the time periods 2001–2017 and 1986–2017, respectively. Likewise, forest areas converted to farmland were 2% between the time periods 1986–2001, but drastically increased to14% and 25% between 2001–2017 and 1986–2017, respectively. The total percentages of land cover types converted to farmland between 1986–2001 was 7.5% and that of the periods 2001–2017 and 1986–2017 were 9.3% and 22.4 %, respectively. Overall, about 22.4% of different land cover types were transformed to farmland during the periods of analysis.

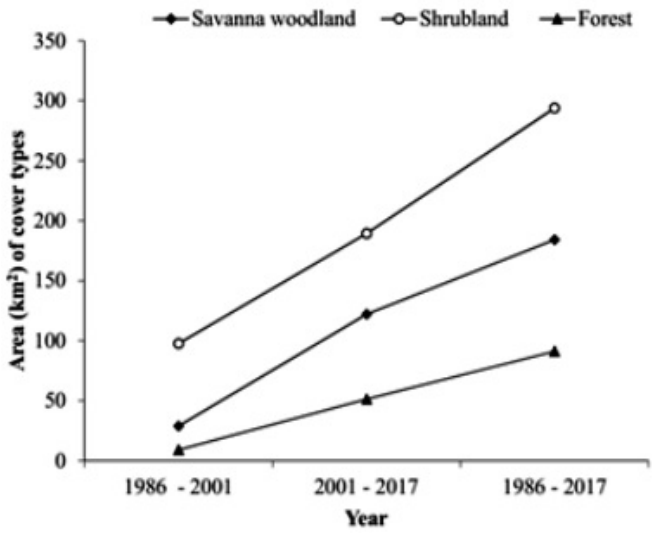

Figure 4. Trends of possible buffalo habitats changed into farmland during the period 1986-2017.

Respondents View of Human Impacts on Buffaloes

Respondents pointed out that, the causes for localized distribution and the range collapse of buffaloes were increased human population (84.5%) and agricultural land expansions (81.2%), followed by bushmeat hunting (50.7%) and illegal trophy hunting (38.6%). Respondents also added that fire (35.3%), tsetse fly (24.2%) and legal trophy hunting (14.5%) have significantly affected the distributions of buffaloes in DDRVs. As replied by most respondents, African elephants, reedbucks, African wild dogs and lions were common in DDRVs, but all of them except lion have been extirpated.

Respondents' perceptions varied about the cause of range collapse and localized distribution of African buffaloes in the DDRVs. Most respondents from Meko and Chewaka districts confirmed that increasing human population, agricultural land expansions and illegal trophy hunting were the main causes of range collapse and localized distribution of buffaloes. Respondents from Dabo Hana district stated that increasing human population (65.2%), illegal trophy hunting (65.2%) and agricultural land expansion (63.0%) have highly affected the buffalo range and distribution. Most respondents from Belo Jeganfoy supported the impact that high human population (94.3%) and agricultural land expansion (83.3%) had on African buffaloes in the DDRVs. Besides, they stated that bushmeat hunting (67.9%) posed a significant impact on African buffaloes and on other large mammals. Tsetse fly was reported to affect the distribution of buffaloes in Meko, Chewaka and Belo Jeganfoy, whereas legal trophy hunting was reported only from Dabo Hana districts. The views of respondents about the causes of range collapse and the current localized distribution of buffaloes among the four districts differed significantly (χ^2= 176.18, df=18, $P < 0.05$). Some respondents from Chewaka districts witnessed that crop raiding, human injuries and mortalities due to buffalo attack were increasing. As reported by household respondents, 16 and 10 individuals were injured and killed by buffaloes, respectively, from the year 2008–2016. In the same period, data obtained from the local health centre also showed that a total of 19 individuals injured by buffalo has been admitted for treatment out of which 3 of them were referred for further medication.

DISCUSSION

Historical and Current Buffalo Ranges

The reconstruction of historical and current records of African buffalo distribution showed that Cape buffaloes occurred widely throughout DDRVs before 1990s. During the Derg regime, because of the vast arrays of wild animals, parts of the DDRVs were designated as Didessa Wildlife Sanctuary. Didessa Dabena River Valleys were considered as a wildlife zone that fits best for monkeys, to indicate the extent of its forest coverage (Dunlop 1937). However, due to the disappearance of most wildlife habitats, only 200 km^2 of the previous Didessa Wildlife Sanctuary is recently designated as Haro Aba Diko Controlled Hunting Area with especial focus on African buffaloes. Though small parts of DDRVs have been designated as a controlled hunting area, much of the area hosting African buffaloes and other wildlife is left westwards along the Dabena River banks, in Qoddi Gassi (Meko district) and in Chewaka district closer to Dabena River. The distribution of African buffaloes gradually contracted and localized as most of their former core habitats are occupied and modified by humans. Currently, the distribution of African buffaloes is limited along the middle Didessa River bank due to extensive agricultural activities and habitat loss. Hence, the displacement of buffaloes from the Didessa River bank into Dabena River and surrounding areas shows the extent that buffalo ranges are contracting due to the synergistic interactions of multiple factors.

To rescue Jorgo-Wato buffaloes, a corridor would have to be designed between JWPF and DDRVs in order to increase movement of buffaloes and gene flow between the two areas. To realize this, the second route (Qoddi Gassi-Homa Chalte-Mount Chalte-Mount Jallo-JWPF) could be the potential corridor to connect the two areas, though few inhabitants along the corridor become problematic as reported by Ogutu et al. (2012). Human settlement and blockage of wildlife endangers the future survival of buffalo populations in the two areas. As revealed by Newmark (1993) and Campbell et al. (2000), if protected area lacks wildlife corridor, genetic drift and inbreeding may lead to population instability and possibly to local extinction. Furthermore, the survival of buffaloes in a confined area of JWPF is the cause of the present human–buffalo conflicts in the area. As JWPF is not big enough to accommodate the home range of Cape buffaloes, free lands that are not convenient for agriculture should be added to the forest as a buffer zone.

Land-Use/Land Cover Class Analysis

Land–use/land–cover changes during 1986–2017 showed that each land–cover types experienced positive or negative changes. Most of the land–cover types showed both negative and positive changes except farmland and savanna woodlands, which exhibited consistent positive and negative changes, respectively, throughout the three evaluation periods. Savanna woodland and shrubland were the dominant land–cover types in the middle of DDRVs and highly subjected to anthropogenic pressure. The conversion of the two land–cover types into farmland contributed more for the expansion of farmland and residential areas over the past 32 years. This could be attributed to human preferences for shrubland and savanna woodland habitats for encroachment, livestock farming and agriculture, and drought driven resettlement programme of farmers from the eastern and western parts of Hararge (Debela 2015). This has a significant impact on buffaloes and other large mammals as it has been conducted in the potential wildlife areas. Implementation of the formal resettlement in the core wildlife habitat may also reveal a lack of balance between conservation and resettlement programmes or poor or no inter-sectoral coordination among concerned professionals. Moreover, after resettlement, land–use system of settlers was not monitored and controlled, and these have led to the periodic destruction of wildlife habitats through shifting cultivation. The total extent of land–cover types converted into farmland was about 22.4%, which could have a pronounced effect on wildlife ranges and survival of large mammals like buffaloes as the change occurred in the core wildlife ranges. In the present study, about 25% of the forest cover was transformed into farmland. This could be attributed to the gradual destruction of forests through shifting cultivation. As revealed by Naughton-Treves et al. (2011), local communities around protected areas usually practice subsistence shifting agriculture and depend on forest products in Africa.

Forest cover was reduced during the period 1986–2001, but increased during the period 2001–2017. The reduction of the extent of forest during 1986–2001 could be partly attributed to Didessa state farm, and the period of political instability in Ethiopia, during which mass of people move down to DDRVs for land grabbing and practiced shifting cultivation. However, the later increase in forest cover could be attributed to the extensive plantation of exotic species such Eucalyptus, and the political stability of the country. Furthermore, the government gave due attention for soil conservation

through afforestation of bare lands. As stated by ORS (2002), some of the old Didessa state farms were covered with mango and Eucalyptus plantations. The utilization of forested areas for coffee plantation coupled with aforementioned reasons could be accounted for the increased forest cover around most highland escarpments and few lowland areas of DDRVs (Figure 2, LULC changes of 2017). As described by Sima (2011), the Didessa River basin is one of the relatively undeforested parts in the western parts of Ethiopia holding about 25% of forest cover though the area is currently under severe human pressure. Similarly, a study conducted during the same periods in Guassa Community Protected Area, Ethiopia, showed an increase in forest cover between the periods 1986-2013 (Moges and Balakrishnan 2014).

Shrubland, savanna woodland and forest cover types were the three most possible habitats of buffaloes that contributed large areas to be transformed into farmland over the past 32-year period. Land–use/ land–cover changes related to shrubland and savanna woodland have negatively influenced buffaloes and their ranges as both these cover types are preferably utilized by buffalo more than the other cover types. Hence, an intense human pressure on these cover types could have gradually pushed buffaloes towards the current core buffalo habitats and the nearby forested habitats of JWPF. Range loss and restrictions, degra-dation of wildlife habitats and anthropogenic pressures are the causes of worldwide temporal or spatial migra-tion of ungulates (Msoffe 2010). However, the survival of Cape buffalo in pure forested habitats of JWPF could be explained as behavioural adaptation and a response to human induced pressure on their former savanna woodland habitats. As the former habitats of buffaloes have been overrun by formal resettlements, encroachments and agriculture, wild animals were forced to make partial or full migration to the nearby or distant potential areas. Large mammals such as African buffaloes require large home ranges in order to fulfill their nutritional requirements. The home ranges of wild animals are reduced due to the expansion of farmland, settlements, habitat loss and fragmentation in and outside protected areas (Goldman 2009, Aryal et al. 2014), which eventually lead species into local extinction (Goldman 2009). In the DDRVs, similar incidences have caused local extinctions of African wild dog (*Lycaon pictus*), reed bucks (*Redunca redunca*) and African elephants (*Loxodanta africana*); rarity of lions (*Panthera leo*), and reduction and/or partial migration of African buffaloes. Similarly, an increase in human population around the western parts of Serengeti National Park has modified the natural habitats into cropland and grazing land, resulting in local extinctions of species (Kideghesho et al. 2006). An increase in world population and demand for food has accelerated the conversion of natural habitats into agricultural land (Foley et al. 2005) especially in developing countries (Lambin et al. 2001). An increase in farmland, resettlements and encroachments in DDRVs have been reducing wider areas of natural habitats available for wild animals. Expansion of settlements and farmlands in protected areas could have a severe and long lasting negative effect on wild animals because it is irreplaceable as reported by McGranahan and Satterthwaite (2003). Hence, small increase in settlement areas has significant impacts on protected areas (Bailey et al. 2015).

Historically, humans did not inhabit the middle Didessa river valley except few indigenous Gumuz people around Didessa-Dabena river junction (Dunlop 1937). These lowland areas have not been convenient to reside and livestock farming due to the widespread occurrence of malaria and trypanosomiasis. However, because of rapid growth of the human population and loss of soil fertility on the highland parts, the lowland areas were extensively used for agriculture (ORS 2002). Consequently, during the past three to four decades, encroachment, agricultural practice and livestock farming have been increasing in the DDRVs (Gebeye 2016), where all permanently uncultivated and unoccupied land have been considered as no man's land. It became more susceptible to encroachment and investment ignoring wildlife. Moreover, the eradication of tsetse fly (Jemal and Hugh-Jones 1995) and availability and accessibility of health centres have made DDRVs more conducive for human survival. In addition to illegal settlement, formal resettlement has been increasing in the potential wildlife areas of DDRVs. This was accompanied by many anthropogenic activities that affect wildlife habitats, distribution, diversity and activity pattern of animals. Many animals have experienced range shifts or contraction (Zhang 2013), extirpated or declined in and outside protected areas due to human impacts and associated climate change (Li et al. 2015). In Rombo, Kenya, human settlement was the cause of the reduction of elephant range (Afolayan 1975). In Ethiopia, impacts of human on wildlife and wildlife habitats are increasing from time to time because people migrate towards the borders of protected areas seeking fertile soil and livestock grazing land (Vreugdenhil et al.

2012). Most protected areas in Ethiopia are poorly managed and thus increasingly degraded. In Ethiopia, protected grasslands are used for livestock grazing, and forested areas are threatened by subsistence and commercial agriculture (Young 2012).

Respondents View of Human Impacts on Buffaloes

In the present study, in addition to the impacts of LU/LC changes, the synergistic interactions of multiple human pressures were recognized as causes of range collapse and localized distribution of African buffaloes and other large mammals. Respondents and observed incidences in the area have also revealed the practices of bushmeat hunting and illegal trophy hunting of buffaloes in DDRVs. As stated by respondents, bushmeat hunting was carried out by local poachers or local militias, whereas most illegal trophy hunters of buffalo come from the remote parts of Limu, Gidda Ayana and Ebantu districts of the East Wollega Administrative Zone. Illegal trophy hunters who come from distant areas did not engaged in poaching alone because of security reasons, but cooperate with the local poachers. However, sometimes, they purchase new trophies of buffalo (forehead hide with horns and tail) from local poachers, but keep the secret as purchased trophy has no social value and acceptance as per the customs of the society. Along with other factors, bushmeat and illegal trophy hunting of buffaloes could have forced them to migrate into JWPF, a finding which coincides with DeBoer et al. (2000), who found that illegal hunting of African elephants in the Maputo Elephant Reserve, Mozambique, forced them to shift their habitat from savanna into forested habitats. Illegal hunting is the cause for the global, regional and local decline of wild animals (Loibooki et al. 2002).

In the present study area, fire was periodically used to clean around residential areas, for wild honey collection and poaching, which could drive large mammals such as buffaloes to the higher forested escarpments of DDRVs, riverine forest and open areas where they are easily targeted by poachers. Tsetse fly is also reported by lowland resident respondents (Chewaka, Meko and Belo Jeganfoy) to have an impact on the distribution of African buffaloes. The prevalence of tsetse flies and biting flies were highest during spring and autumn in the lowland parts of DDRVs. During this period, African buffaloes move and stay in the highland forested escarpments to avoid bites of tsetse flies. Such tsetse fly avoidance behaviour may further extend the movement of buffaloes to areas where they have not survived before like JWPF. Haro Aba Diko is a controlled hunting area where legal trophy hunting is conducted under Oromia Forest and Wildlife Enterprises since its establishment in 2010 (Vreugdenhil et al. 2012). As stated by most respondents of Dabo Hana districts, trophy hunting has an impact on range reduction and distribution of African buffaloes because they respond to gunshots and mostly fled out of the hunting zone. This may lead to permanent spatial range shift towards safer areas. Hence, areas into which buffaloes fled during trophy hunting should be included into the Haro Aba Diko Controlled Hunting Area to secure them from illegal poachers.

In DDRVs, the views of respondents about the causes of localized distribution and the range collapse of buffaloes were different. This could be attributed to variation in the location of residents and access to the current buffalo ranges in DDRVs. For instance, Chewaka is a new district established in 2002, in the centre of DDRVs, in line with settlers who come from the eastern and western parts of Hararge. As, resettlement has been carried out along perennial water sources, it could reduce or hinder buffaloes and other mammals access to water points as reported by Ayeni (1975). This could be the reason for increased human–buffalo conflicts in Chewaka than other districts.

CONCLUSION

Cape buffaloes have possibly invaded JWPF in the early 1990s. The source is supposed to be the QoddiGassi of the DDRVs because it is the only buffalo range located in close proximity to JWPF. African buffaloes have been widely distributed in the entire DDRVs since the historic time. However, because of increasing encroachments, human resettlements, poaching for bushmeat and trophy hunting, and due to agricultural extension buffalo distribution became localized only to few remnant potential areas of the DDRVs such as Haro Aba Diko Controlled Hunting Area, along the Dabena River banks, Qoddi Gassi and around Gara Samen parts of Chewaka districts. The contraction of buffalo ranges was evident from the reduction of buffalo habitats such as shrubland and savanna woodland habitats and the increase of farmland and residential areas over the former ranges. Hence, the impacts of human induced pressures in the DDRVs might have forced buffaloes to partially migrate to the nearby forested areas like JWPF. In JWPF, Cape

buffaloes are highly vulnerable to inbreeding depression, which gradually leads to local extinction of the species. Hence, a corridor should be designed between JWPF and QoddiGassi of the DDRVs in order to increase gene flow between the two populations. Haro Ababa Diko Controlled Hunting Area should extend to the Qoddi Gassi, the Dabena River bank and the GaraSamen region of the Chewaka district as these areas are known to host more wildlife including African buffaloes. Moreover, resettlement programmes conducted in the DDRVs should consider a balance between wildlife conservation and other public aspects through the involvement of professionals of different sectors. Alternative economic opportunities, expanding modern farming system and development of industry should be practiced to overcome the recent recurring drought driven resettlement programmes in wildlife habitats.

ACKNOWLEDGEMENTS

We thank Addis Ababa and Wollega Universities for providing financial support. We are also grateful to Oromia Forest and Wildlife Enterprise for allowing this research to be conducted in Jorgo-Wato Protected Forest and Tesfaye Muluneh for his technical assistants in land-use/land-cover change analysis.

Author Contributions: The first author was involved in data collection, statistical analysis and write up of the paper. The second and third authors supervised the research work and structured the manuscript

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Received 17 December 2018
Accepted 12 February 2019