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RESEARCH ARTICLE

DISTRIBUTION AND HABITAT ASSOCIATION OF SOMALI OSTRICH IN SAMBURU, KENYA

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Abstract

Somali ostrich has recently been published as distinct species. The bird is undergoing a drastic decline in population and thus classified as Vulnerable by IUCN. Its conservation demands an urgent understanding of the scope and the severity of the prevailing threats. The decline in range is an important threat to survival and propagation of wild populations in Samburu landscape. We aimed at identifying critical ranges and habitats utilized by the species by investigating its distribution and habitat association within Meibei and West Gate Conservancies, and Samburu National Reserve. Global Positioning System (GPS) coordinates and habitats types were recorded for all ostrich sightings during surveys conducted along predetermined routes in the study area. The Normalized difference vegetation Index (NDVI) at ostrich sighting points were obtained and regressed with the frequency of ostrich observations and the resultant regression models used to generate a spatial distribution model map. Somali ostriches were found to prefer bushy areas to open grasslands. However, they avoided think vegetation probably for predator avoidance. Majority of ostrich coexist with Samburu pastoralists and their livestock. This overlap suggests that any meaningful Somali ostrich conservation planning should focus on the involvement of the Samburu pastoral communities in land use planning.

Introduction:-

The natural distribution of animal species within a geographical range has been closely associated with array of factors, including availability of resources such food, water and mates, habitat structure, competition, predation pressure as well as microclimate (Begonet al., 1996; Elmouttie, 2009). Whittaker (1975) showed that distribution patterns of species are a response to environmental gradient. For example, it has been documented that habitat heterogeneity and topography (Kerr and Parker, 1997), dispersal (Svenning et al., 2008b), biotic interactions (Aroujo and Luoto, 2007; Kisslinget al., 2007) and climate (Svenning and Skov, 2007) play key roles in determining species distribution. However, as the survival of a species is fundamentally based on its ability to readily access and secure sufficient resources, the spatial and temporal fluctuations of the resources is critical to distribution of both flora and fauna (Elmouttie, 2009). Distribution of animals fluctuates spatially within shorter periods of time than that of the plants. This can be attributed to animals' ability to move and adapt quickly to changes in resource availability. Thus, the patterns of distribution of animals can be explained by heterogeneity in resource distribution.

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Krausman (1999) defines habitat as the resources and conditions present in an area that produce occupancy, including survival and reproduction, by a given organism. Physiological and environmental requirements of an organism impose restrictions of its spatial occupancy (Aartset al., 2007). The type of habitat is often a function of the constituent plant communities that determine the physical structure of the environment. It has been shown that structurally complex habitats may provide more niches and thus host an increased diversity of species (McCoy and Bell, 1991). For example, a positive relationship between vegetation based-heterogeneity and animal species diversity has been documented (Davidwitz and Rosenzweig, 1998). Although many studies, have demonstrated the association of species with edaphic and topographic factors (Valencia et al., 2004; Yamada et al., 2006; Queenboroughet al., 2007), it has been shown that plant community structure play a critical role in influencing the distribution and habitat selection by animals (McCoy and Bell, 1991). A key component of vegetation structure is canopy structure whose temporal and seasonal patterns show variations that have been recently described by radiation absorption by the canopy (Wang et al., 2004). Measurements of the absorption determined by the difference in chlorophyll reflectance between the visible and near-infrared parts of light spectrum (Tarpley et al., 1984). The difference expressed as a ratio of the total reflectance is known as Normalized Difference Vegetation Index (NDVI). Although mathematically NDVI ranges from -0.1 to 1.0 the actual measurements on the earth's surfaces does not exceed 0.7. (Suzuki et al., 2001). NDVI has successfully been used in studying spatial and seasonal variations in vegetation 'greenness' (Gutman, 1999).

Generally, ostriches occur naturally on Savannahs and semi-deserts. Their distribution is almost independent of water as they can withstand a considerable degree of dehydration (Cloudsley-Thompson and Mohamed, 1967). Due to their size and preference for more open habitat types, they are regularly encountered in wildlife areas where they frequently associate with other herbivorous animals. One such area is Samburu Community lands in Kenya where Somali ostrich occur (SCRI Annual Report, 2004). Until recently, taxonomists considered all ostrich races as a single species –*Struthiocamelus*. Under this taxon, five subspecies were recognized (Cooper et al., 2015). These were Somali ostrich, (*Struthiocamelusmolybdophanes*Reichenow), Southern ostrich (*Struthiocamelusaustralis* Gurney), North African ostrich (*Struthiocameluscamelus*Linnaeus), Masai ostrich (*Struthiocamelusmassaicus*Neumann) and the extinct Arabian or Middle Eastern ostrich (*Struthiocamelussyriacus*Rothschild). However, Molecular studies of both the extant and extinct forms (Freitag& Robinson, 1993; Kimweleet al.,1998; Kumari and Kemp, 1998) of Struthiotaxa have shown that the Somali ostrich is phylogenetically the most distinct (Robinson and Matthee, 1999) and divergent of the ostrich subspecies (Freitag& Robinson, 1993). Thus, Somali ostrich has recently been recognized as a distinct species, *Struthiomolybdophanes*(BirdLife International, 2014). Its first assessment as a species by International Union for Conservation of Nature (IUCN) has revealed that its population is declining rapidly and thus listed as vulnerable species in IUCN red list of endangered species (BirdLife International, 2014). Meanwhile, *Struthiocamelus* has remained listed as species of Least Concern because does not meet any of the IUCN criteria for Vulnerable threshold. Despite evidence of drastic declines in population of *S. molydophanes*,most studies on ostriches have been focused on the species *Struthiocamalus* while the former has remained largely ignored. The information on its ecology, conservation status, distribution and threats is yet to be documented. The general aim of this study was to investigate seasonal and spatial variations in distribution and habitat association of Somali ostrich within Meibei and Westgate Community Conservancies and the adjacent Samburu National Reserve.

Materials and Methods:-

Study area

The study was conducted in Meibei ($0^0$47'51.3" N $37^0$05'57.5" E) and Westgate ($0^0$44'20.0" N $37^0$21'08.8" E) Community Conservancies and the adjacent Samburu National Reserve ($0^0$36'49.5" N $37^0$32'16.3" E) in Samburu County, Kenya (Fig. 1). The study area has bimodal rainfall distribution with long rains from March to May and short rains from November to December. The mean annual rainfall is 500mm and mean annual temperature is 29^{o}C. The dominant vegetation types are grassland vegetation and a mixture of acacia and thorn trees. The main economic activity is pastoralism with livestock, mainly cattle sheep, goats, donkey and camels sharing grazing areas with wildlife.

Determination of distribution and habitat association of the Somali ostrich

Ostrich studies were carried out once every fortnight from June 2014 to June 2015 by driving through the study site along predetermined routes. For each sighting, the number of birds (group size), global positioning system (GPS) position, and time were recorded. Birds observed within 100m of each other (Magigeet al., 2008) and portraying

similar general behavior for example moving in the same general direction were regarded as one observation. Sex of the adult birds and age were recorded using the following criteria:
1. Adults > 2 years; females brown and males black and white
2. Juveniles < 2 years; slightly smaller than adults and brown in colour
3. Chicks < 3 months; black speckled white and follows mother closely.

Habitat types were also recorded. Habitats were categorized as open grasslands, low bush, medium bush, high bush and riverine according to Kikula (1980) and Caro (1999).

Normalized Difference Vegetation Index (NDVI)
The Normalized Difference Vegetation Index (NDVI) layers, 16-day interval with resolution of 250m, for Samburu landscape was acquired from the NASA's Earth Observing System Data and Information System (EOSDIS) portal. Dates of ostrich field observations in dry and wet seasons were used to guide on appropriate periods for NDVI downloads. This ensured NDVI variability that occurred in dry season and wet seasons were captured. Layers that coincided with dry and wet seasons were averaged in order to harmonize variation of NDVI that occurred between months. Additionally, the Ostrich observations with their spatial references were combined together for each of the two seasons.

ArcGIS was used for data manipulation and general geo-processing in order to come up with required quality of data. The NDVI layers were resampled to 1km resolution so as to generalize vegetation index over a considerable landscape. Point value extraction tool in ArcGIS was used to extract NDVI values from NDVI layers using the species spatial reference points. Thus, each value of NDVI extracted coincided with the values of ostrich observation.

Least Square Method was used in modeling the distribution of the ostrich over the wider landscape by fitting point values using regression equation (y=ax + b). The coinciding values of ostrich group size and NDVI were used to generate regression model; with the former considered as response variable and the latter a predictor variable. This model was then used in an ArcGIS raster calculator to generate a spatial model of ostrich distribution over the NDVI for a wider landscape.

Data analysis
Descriptive statistics (mean, percentages, range, standard error and standard deviation) were used to describe and summarize data into tables and figures. Chi square test was used to determine significance of differences between ostrich observations in different types of habitats at 0.05 significance level. Normality of the NDVI values downloaded was tested using Shapiro-Wilk test (Shapiro and Wilk, 1965). Pearson's linear regression analysis were performed between NDVI and frequency of ostrich observations in different study areas and seasons. The analyses were performed by using the PALeontologicalSTatistics (PAST) Version 3.10 (Hammer et al., 2001). Data are presented as mean ± standard error.

Results:-

Habitat association
Overall results showed that majority of ostriches were observed in the medium bush (n = 159) and low bush (n = 39) which accounted for approximately 69% and 17% respectively. Low percentage observations were recorded in high bush (6.9%) and open grassland (6.0%) with the riverine vegetation recording the least (1.7%) (Fig. 1.1).

Observations recorded in both Samburu National Reserve,Meibei and West Gate Community Conservancies, and in wet and dry seasons reflected a similar pattern of ostrich habitat association (Table 1). However, variation between the Reserve and the Community Conservancies had a significant difference (χ^2 = 17.25, df = 4, P < 0. 05). It was notable that no observation was recorded in high bush within the Reserve and the percentage observation in medium bush had declined in favour of low bush implying that the ostriches avoided bushy areas in the Reserve. Conversely, variation in habitat association between dry and wet seasons was not significant (χ^2 = 1.53, df = 4, P > 0.05).

Wet season distribution models
Ostrich occurrence decreased with the increase in NDVI values in wet season (Slope=-28) (Fig. 4.6a). Using Pearson's linear regression, the ostrich observation was confirmed to be negatively correlated to recorded values of NDVI (r = -0.279). Regression analysis performed on the ostrich observations and NDVI values for wet season

generated a model which was extrapolated into spatial distribution model for wet season. The model shows a higher density of ostriches in the northern side than in the southern side of the study area (see colour gradient) (Fig. 4.6b). The southern area corresponds to Samburu National Reserve and has very low ostrich densities.

When female ostrich observations were correlated to the NDVI values, a negative correlation was also obtained (r=-0.42) implying that the number of observations and group sizes of female ostrich declined with increase in NDVI values. The spatial distribution model obtained indicated that more female ostriches are likely to be found in community conservancies than in protected area. Relatively higher densities of female ostriches likely to be found at region coinciding with North of West Gate and south- west of Meibei extending all the way to North east of Meibei. The density declines southwards of West Gate Conservancy towards the Samburu National Reserve. The lowest female ostrich densities represented by different shades are likely to be realized in North West of Meibei, South east of West gate and Southern part of Samburu National Reserve (Fig. 4.7a).

Observation for larger group sizes of male ostriches were made more frequently at higher NDVI values subsequently producing a positive correlation (r=0.69). The wet season spatial model for male ostriches shows that males are likely to occur in three main clusters; the Southern region of Samburu National Reserve, South-eastern region of west Gate and Western part of Meibei (Fig. 4.8b). It was notable that the regions in which males are likely to occur in relatively high densities, corresponds to areas in which females are likely to occur in low densities (Fig.4.7b).

Dry season distribution models

Ostrich spatial distribution model generated for dry season showed similar results to wet season in which majority of ostriches are likely to be observed in community conservancies. However, in this season the density of ostrich that are likely to be observed in Samburu National Reserve are higher than in wet season and more spread and therefore ostriches are likely to sighted in most parts of the study area (Fig. 4.9b).

When males and females are considered separately, the distribution models show a more or less similar pattern of distribution (Fig. 4.10). High densities for the both sexes are likely to be observed at the region north of West gate conservancy and south of Meibei conservancy. The rest of the study area including; southern part of West Gate, Samburu National Reserve and the western side of Meibei is covered by varying but relatively lower densities of Somali ostrich (Fig. 4.10). In some areas (Fig. 4.10) the likelihood of sighting an ostrich of either sex is zero. The correlation between ostrich group size and NDVI values for females was significant (r =-0.41, p=0.02) while that of males was not significant (r = -0.10, p=0.57).

Discussion:-

Habitat association

Most of Somali ostriches were observed in the medium and low bush areas suggesting that the preferred habitat for the bird is bushland. This is in contrast to their Kenyan counterpart, the Masai ostrich whose preferred habitat is open grassland (Freitag& Robinson, 1993; Magige, et al., 2012). Somali ostrich being a browser (Freitag& Robinson, 1993), it is more likely to occur in middle-height vegetation where it obtains food. The results of this study showing that the ostrich was rarely observed in the high bush and riverine vegetation is consistent to findings by Bertram (2014) that ostriches generally avoid areas of thick bush or heavy tree cover. Lack of significance difference in frequency of observations between wet and dry season is an indication that seasonality does not influence the type of habitat associated with Somali ostrich in Samburu. Conversely, difference in ostrich observations in the five classes of vegetation studied between Samburu National Reserve and Community Conservancies was significant with ostriches preferring less bushy areas in the community areas than in the reserve. This can be attributed to differing predation pressure between the two study areas. Risk of predation is an important factor in determining selection of habitat by herbivores especially when the risk varies among habitats with different levels of vegetation complexity (Burkepileet al., 2013). One of the main antipredator response by prey is increased vigilance (Brown and Kotler, 2004) enhanced by choice of safer habitats (Sih, 1997) such as less closed habitats. Studies have shown that large predators do well in protected areas but poorly in community lands (Woodroffe, 2001; Ogutu& Dublin, 2002). Therefore, it can be concluded that the Reserve host higher densities of predators than Community Conservancies and therefore avoided by prey animals such as Somali ostrich.

Spatial distribution model maps for Somali ostrich in dry season
The negative correlation between NDVI and frequency of ostrich observation further confirms that ostriches generally prefer open habits to close ones (Freitag& Robinson, 1993). It also confirms validity of observatory results in which few observations of Somali ostrich were made in thick bushes. The spatial model maps generated shows that the highest densities of ostriches are distributed in regions that correspond to densely settled areas in the Meibei and Westgate Conservancies. This finding suggests that Somali ostrich coexist with pastoralists probably to benefit from protection against the predation offered to livestock. Indeed, substantial numbers of ostriches were observed feeding around and within deserted homesteads (Pers. obsev.). Similar trend of distribution was observed in Grevy's zebra (*Equusgrevyi*) in the same area. An aerial survey reported that 60% of the Grevy's zebra occur among the pastoral communities (Low et al, 2009). Although a recent study by Letoiye (2014) shows a strong negative correlation between human settlement and Grevy's zebra movements, Williams (2002) had argued that at night while livestock are enclosed in their corrals, Grevy's zebra graze close to homesteads to evade predators.

During wet season, the distribution of ostriches is less spread than in dry season. Food resource availability is a possible explanation for this kind of observation. When food supply is adequate, the distribution becomes a function of factors other than food. Predation is one such factor that influences distribution of large animals in Samburu landscape. It has been found the predator densities are higher in the protected areas. Thus, in Samburu there is tendency of prey animals to move away from the Reserve to community conservancies (Low et al., 2009) where predators are less abundant. Female spatial model distribution maps for both wet and dry seasons as well as that for males during the dry wet season are more or the less similar to the model maps for all the ostriches combined. Studies have shown that females of Grevy's zebra closely track the distribution of resources in the landscapes, compared to males which are typically territorial (Rubenstein, 1986; Sundaresanet al., 2007a) and thus they are more likely to determine general distribution of the species. Somali ostrich females appear to have a similar influence to overall distribution. However, the distribution for males in wet season has a distinct pattern from the rest. Males being territorial, and particularly during the breeding season (Magigeet al., 2008), are expected to occupy their territories away from the rest of ostriches. It is seen from spatial distribution models, that males form distinct patterns near rivers and hills. Probably these are regions of high resource availability or they are optimal habitats for breeding in which males form their territories in order to attract females.

It is therefore recommended that identified regions within Meibei and West Gate Conservancies where Somali ostriches occur in high densities should be reserved for the conservation of the species. Corridors should be established connecting the two conservancies and the reserve where ostriches apparently move for dry period refuge. Further, the community based conservation is proposed since Somali ostrich range overlaps with that of the people of Samburu and their livestock. Conservation planning should therefore aim at involvement of the Samburu pastoral communities in land use planning with view of preserving optimal habitats of Somali ostrich.

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We wish to express our gratitude to the owners and management of West Gate and Meibai community conservancies and Samburu National Reserve for granting us free access into study area. We thank Simon Loloolki who helped in field data collection. The warm hospitality of Samburu Community cannot go unmentioned. We enjoyed working with Morans and conservancy scouts who served as field guides and also provided security.

Fig. 1:- A map of Study area showing Samburu National Reserve, West Gate and Meibei (consisting of Barsalinga, Lpus, and Ngaroni) Community Conservancies.

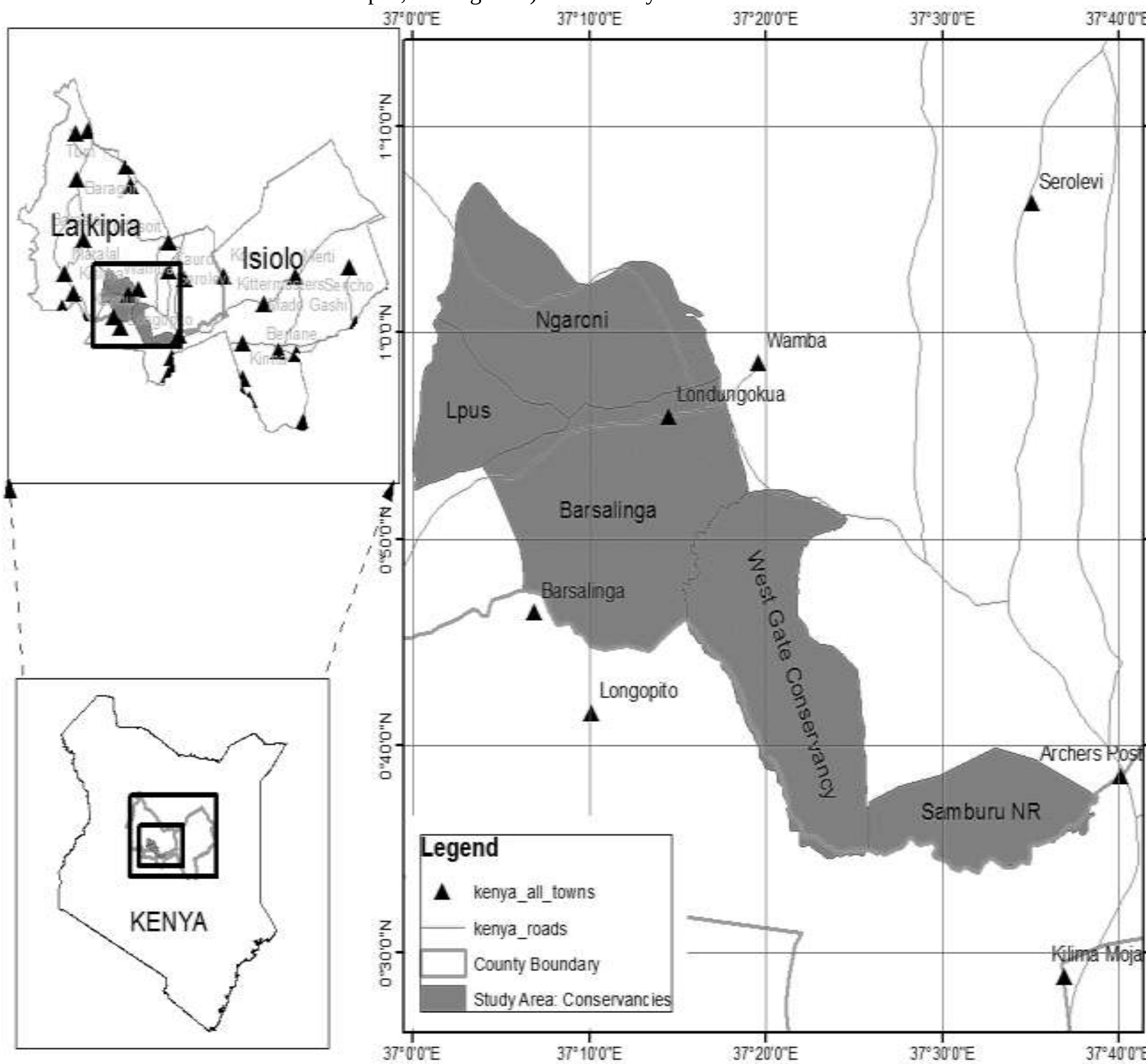

Table 1:- Somali ostrich observation in Community Conservancies and, wet and dry seasons in Samburu National Reserve, Meibei and West Gate Community Conservancies.

Veg. type		**CC**		**SNR**		**Dry**		**Wet**	
		Observ.	**%**	**Observ.**	**%**	**Observ.**	**%**	**Observ.**	**%**
Open grass		11	5.9	3	7.3	8	6.6	6	5.4
Low bush		28	15.0	11	26.8	22	18.2	17	15.3
Med. bush		135	72.2	24	58.5	79	65.3	80	72.1
High bush		12	6.4	0	0.0	9	7.4	7	6.3
Riverine		1	0.5	3	7.3	3	2.5	1	0.9
Total		**187**	**100**	**41**	**100**	**121**	**100**	**111**	**100**

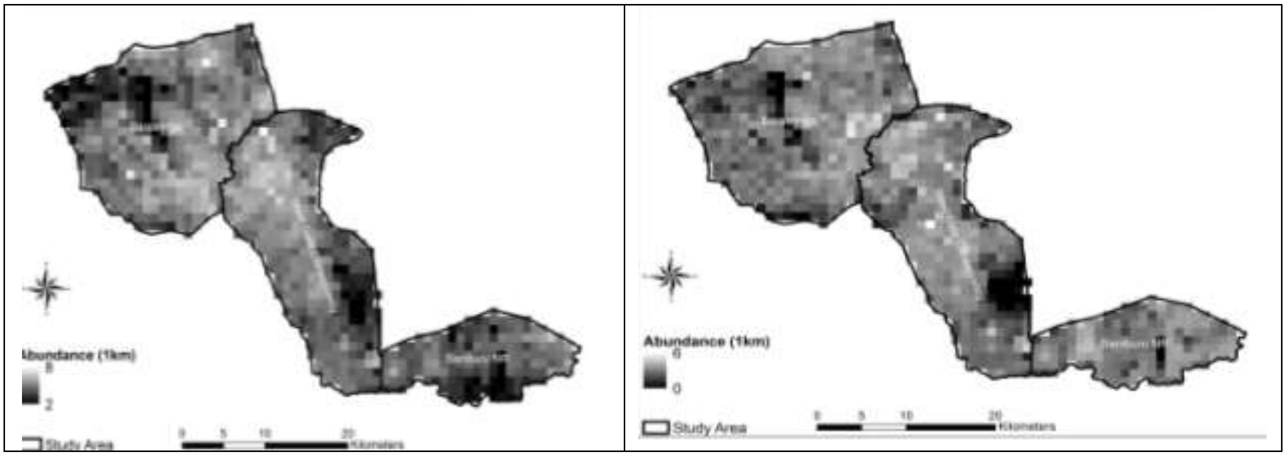

Fig.2:- Potential distribution of Somali ostriches in Samburu landscape in (a) wet season and (b) dry season in Samburu National Reserve and Meibei and West Gate communityconservancies.

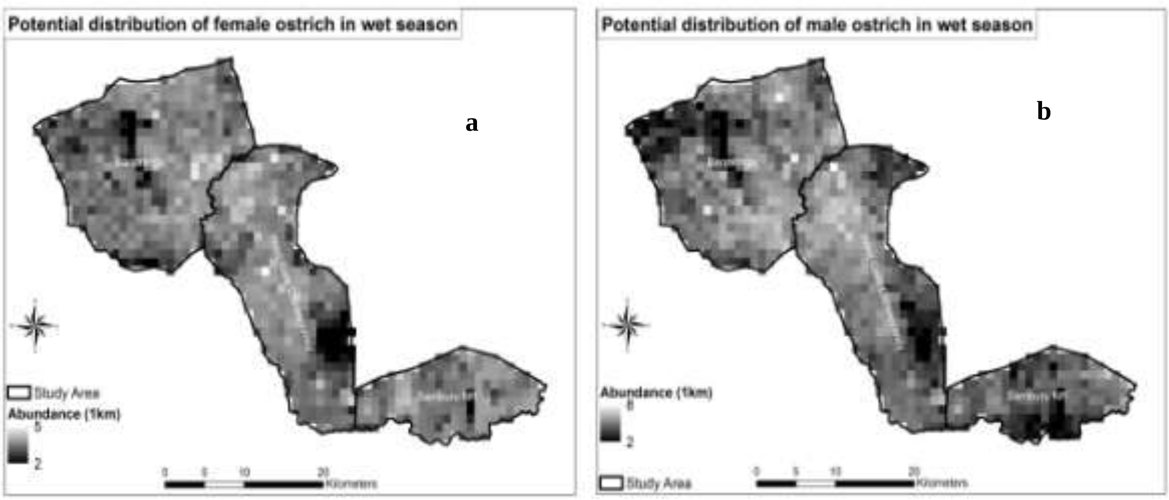

Fig.3:- Potential distribution of (a) female ostriches and (b) Male ostriches during wet season in Samburu National Reserve and Meibei and West Gate community conservancies.

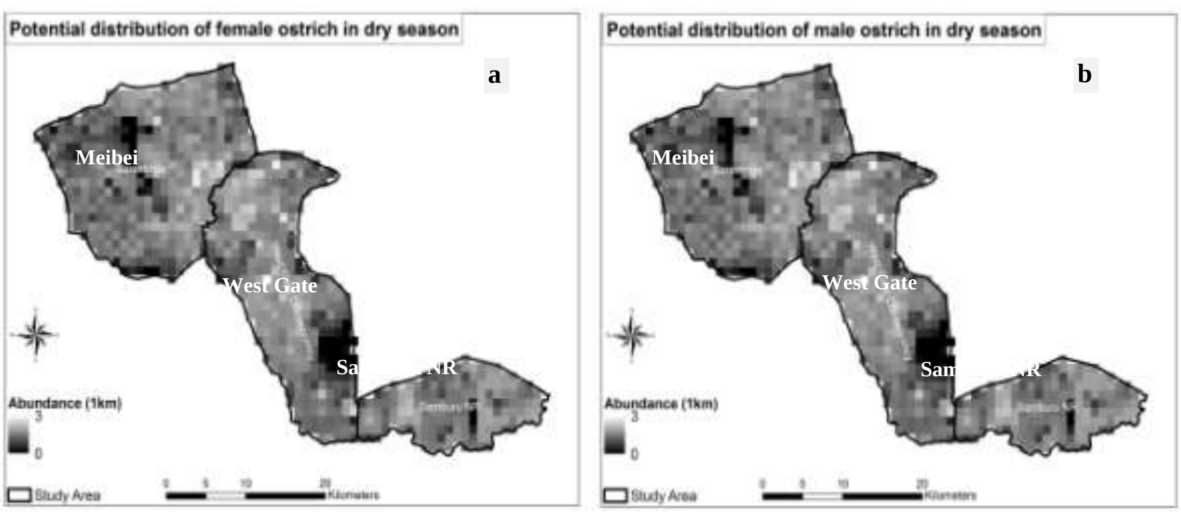

Fig.4:-Potential distribution of (a) female ostriches and (b) Male ostriches during dryseason in Samburu National Reserve and Meibei and West Gate community conservancies.

References:-

1. Araújo, M.B**.** &Luoto, M. (2007). The importance of biotic interactions for modelling species distributions under climate change. Global Ecology and Biogeography 16, 743-753Begon M., Harper J.L. & Townsend C. R. 1996. Ecology: Individuals, Populations and communities. 3rd edition.Blackwell Science.OxfordBERTRAM C. R. B. (2014). The Ostrich Communal Nesting. Princeton University Press.
2. Birdlife International (2013). Ostrich (Struthiocamelus) is being split: List S.c.molydophanes as near threatened or vulnerable? Globally Threatened Birds Forums.Posted in http://www.birdlife.org/datazone/species/factsheet/22732795 on September 4, 2013 by Joe Taylor.
3. Burkepile, D. E., Burns,C. E., Tambling,C. J., Amendola, E., Buis, G. M., Govender, N., Nelson, V., Thompson, D. I., Zinn, D. &Smith, M. D. (2013). Habitat selection by large herbivores in a southern African savanna: the relative roles of bottom-up and top-down forces. Ecosphere 4(11):139. http://dx.doi.org/10.1890/ES13-0007
4. Brown, JS & Kotler, BP (2004). Hazardous duty pay and the foraging cost of predation. Ecol. Lett.7, 999-1014.
5. Cardador, L., Sardà-Palomera, F., Carrete, M. &Mañosa, S. (2014). Incorporating spatial constraints in different periods of the annual cycle improves species distribution model performance for a highly mobile bird species. Diver.andDistrib. 20: 515-528.
6. Caro, T.M. (1999). Densities of mammals in partially protected areas: The Katavi ecosystem of western Tanzania. J. Appl. Ecol. 36: 205-217.
7. Cloudsley-Thompson, J.L. & Mohamed, E.R.M. (1967). Water economy of the ostrich. Nature 216: 1040.
8. Cooper, R.G., Mahrose, K.M., Horbańczuk, J.O., Villegas-Vizcaíno, R., Kennou Sebei, S., Faki& Mohammed, A.E., (2015). The wild ostrich (Struthio camelus): a review. Trop. Anim. Heal. Prod. 41, 1669–1678. doi:10.1007/s11250-009-9364-1
9. Davidowitz, G. &M.L. Rosenzweig (1998). The latitudinal gradient of species diversity among North American grasshoppers (Acrididae) within a single habitat: A test of the spatial heterogeneity hypothesis. **J. Biogeogr.** 25:553-560.
10. Elmouttie D. (2009). Utilization of seed resources by small mammals: A two-way interaction. PhD Desertation.Queensland University of Technology. Australia.
11. Freitag, S. & Robinson, T.J. (1993)Phylogeographic patterns in mitochondrial DNA of the Ostrich (Struthiocamelus). The Auk 110 (3): 614–622.
12. Gutman G. (1999). On the the use of long-term global data on land reflectance's and vegetation indices derived from advanced very high resolution radiometer. J. geophys.Res.104:6241- 6255.
13. Kerr, J. T. & Packer, L. (1997). Habitat heterogeneity as a determinant of mammal species richnessin high energy regions,Nature385: 252
14. Kikula, I.S. (1980). Landsat Satellite Data for Vegetation Mapping in Tanzania: the case of the Rukwa Region. Bureau of Resource Assessment and Land Use Planning, Research ReportNo 41, University of Dar es Salaam.
15. Kimwele, C., GRAVES, J.,(2003). A molecular genetic analysis of the communal nesting of the ostrich (Struthio camelus). Mol. Ecol. 12, 229–236. doi:10.4269/ajtmh.2011.11-0186
16. Kissling, W.D., Rahbek, C. &Bohning-Gaese, K. (2007). Food plant diversity as broad-scale determinant of avian frugivore richness.Proceedings of the Royal Society B: Biological Sciences 274, 799–808
17. Kumari, P., Kemp, J., (1998). Polymorphic microsatellite markers in the ostrich (Struthio camelus). Mol. Ecol. 7, 133–140.
18. Krausman P.(1999). Some Basic Principles of Habitat Use. In 'Grazing Behavior of Livestock and Wildlife.' (Eds K Launchbaugh, K Sanders and J Mosley) pp. 85-90. (University of Idaho: Moscow, USA).
19. Letoiye D. (2014). Participatory spatial planning for reconciling human activities and conservation of Grevy's zebra (Equusgrevyi) in Northern Kenya – a Case Study of MeibeiCommunity Conservancy, Samburu. MRJER 2: 092 – 103.
20. Low B, Sundaresan SR, Fischhoff IR, Rubenstein DI (2009). Partnering with local communities to identify conservation priorities for endangered Grevy's zebra.BiolConserv. 142: 1548–1555.
21. Magige F.J., Holmern, T., Stokke, S.,Mlingwa, C.&Røskaft E.(2009a). Does illegal hunting affect density andbehaviour of African grassland birds? Acase study on ostrich (Struthiocamelus).Biodivers. Conserv.18:1 361-1373 DOI :10.1007/s10531-008-9481.
22. Makishima, H. (2005). Flora and vegetation of Nachola, Samburu District, Northern Kenya: A study of vegetation of an arid land. Afri. Study Monogr. 32: 63 – 78.
23. McCoy E.D. & Bell S.S. (1991) Habitat structure: theevolution and diversification of a complex topic.In:Habitat Structure: The Physical Arrangement of Objectsin Space(Eds S.S. Bell, E.D. McCoy & H.R. Mushinsky),pp. 3–27. Chapman and Hall, London, UK.

24. Rasmussen, H. B.G. Wittemyer, I.&Douglas-Hamilton. (2006). Predicting time-specific changes in demographic processes using remote-sensing data.J. App. Ecol.43:366–376.
25. Robinson T.J. &Matthee, C.A. (1999). Molecular genetic relationships of the extinct ostrich, Struthiocamelussyriacus: consequences for ostrich introductions into Saudi Arabia Anim.Conser.2: 165–171.
26. Rubenstein, D.I. (1986) Life history and social organization in arid adapted ungulates. In: Ecological Aspects of Social Evolution (eds. Rubestein, D.I. and Wrangham, R.W.). Princeton University Press, Princeton, New Jersey.
27. TARPLEY, J.D., SCHENEIDER, S.R. & MONEY, R.L. (1984). Global vegetation indices with from the NOAA-7meteorologicalsatellite.J. Climate Appl.Meteor. 23: 491-494.
28. Samburu Conservation Research Initiative (SCRI) (2004). Annual report. Available at www.earthwatch.org.retrieved on 24th May 2011.
29. Sih A. (1997). To hide or not to hide? Refuge use in a fluctuating environment.Trends Ecol. Evol.12:375-376
30. Sundaresan S.R., FischhofF I.R., Hartung, H.M., Akilong P. & Rubenstein DI (2007). Habitat choice of Grevy's zebras (Equusgrevyi) in Laikipia, Kenya. AfriJ.Ecol 46: 359–364 Switzerland.
31. Suzuki, R., Nomaki, T., &YusunarI, T. (2001). Spatial distribution and its seasonality of satellite derived vegetation index (NDVI) and climate in Seberia. Int. J. of Climatol. 21: 1321 – 1335.
32. Svenning, J.-C.&Skov, F. (2007). Ice age legacies in the geographic distribution of tree species richness in Europe. Glob. Ecol. Bio-geogr., 16, 234–245.
33. Svenning, J-C., Normand, S. &Kageyama, M. (2008). Glacialrefugia of temperate trees in Europe: insights from species distribution modeling. J. Ecol., 96, 1117-1127.
34. Valencia, R., Foster, R.B., Villa, G., Condit, R.,Svenning, J.C., Hernandez, C., Romoleroux, K., Losos, E., Magard, E. &Balslev, H. (2004). Treespecies distributions and local habitat variation in theAmazon: large forest plot in eastern Ecuador.J. Ecol.92: 214–229.
35. Williams S.D. (2002). Status and action plan for the Grevy's zebra (Equusgrevyi). In: Moehlman, P.D. (Ed.), Equids: Zebras, Asses, and Horses: Status Survey and Conservation Action Plan. IUCN/SSC Equid Specialist Group, Gland
36. Whittaker, R.H. (1975). Communities and Ecosystems 2ndedition. MacMillan, USA.
37. Woodroffe, R. (2001). Strategies for carnivore conservation: Lessons from contemporary extinctions. In Carnivore Conservation (eds. Gittleman, J. L.; Funk, S.; Macdonald, D. W. and Wayne, R. K.) 61-92. Cambridge University Press, Cambridge.
38. Yamada, T., Tomita, A., Itoh, A., Yamakura, T., Ohkubo,T., Kanzaki, M., Tan, S. & Ashton, P.S. (2006). Habitatassociations of Sterculiaceae trees in a Bornean rainforest plot.J. Veg. Sci. 17: 559–566.