

BOTSWANA BIODIVERSITY SYMPOSIUM



Sustainable management, utilisation and conservation of biodiversity for economic benefits in a rapidly changing world.

08-10th February 2022, Lobatse, Botswana

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PROGRAMME

Day 1

Director of Ceremonies, [Mr. Stephen T. Mogosi](#)

0730Hrs Registration, ALL

0830Hrs Prayer, [Pastor Rodney Mazani](#)

0835Hrs Introductions, District Commissioner (Lobatse), [Mr Ronald Masole](#)

0850Hrs Welcome Remarks, [Kgosi Tshegofatso Setumo](#)

.....

0900Hrs [Poem](#)

0905Hrs Keynote Address, Minister of Environment, Natural Resources Conservation and Tourism, [Honourable Philda Nani Kereng](#)

0925Hrs Traditional Dance

0935Hrs Keynote Contribution, [Professor Kathleen Alexander](#)
Caracal Biodiversity Centre

0950Hrs Vote of thanks, His Worship The Mayor for Lobatse [Essop Pandor](#)

1005Hrs [Refreshments](#) [Refreshments](#)



Presentations

MORNING

Chairperson

[Dr T.Motlhaodi](#)

1030Hrs

Host plant species most preferred for mistletoe colonization in two urban areas of Botswana –

[Mpho Granny Batlhophi](#)

1045Hrs

Investigating changes in abundance and distribution of Wattled Crane (*Bugeranus carunculatus*) in the Okavango Delta, Botswana – [Charles Mpofo](#)

1100Hrs

Mosquito vector diversity and abundance in Southern Botswana, in a global context of emerging pathogen transmission – [Ntebaleng Makate](#)

1115Hrs

Status and occurrence of Fruit Fly species (*Diptera:Tephritidae*) in the Western Region of Botswana [O. Sithole](#)

1130Hrs

Beyond Power Supply: Prevalence and Distribution of bird nests along the Palapye - Foley transmission power line,Botswana - [Gosiame Neo-Mahupeleng](#)

1145Hrs

Natural infections of Bottle Gourd (*Lagenaria siceraria* Molina Standl.) landraces by three diseases at the Glen valley area,Botswana - [Maatla C. Morapedi](#)

1200Hrs

A preliminary assessment of the distribution of alien invasive plant species in Chobe District, Northern Botswana -[Keotshepile Kashe](#)

1215Hrs

A review of Fish Parasite Diversity in Botswana -[Maxwell Barson](#)

1235Hrs

A quality review of biodiversity inputs for tourism EIAs in Botswana's Okavango Delta - [Leepile L.B.L](#) [Virtual]

1255Hrs

LUNCH

LUNCH



AFTERNOON

- Chairperson:** Dr N.Makate
- 1400Hrs** Morphological variability in Botswana bottle gourd (*Lagenaria siceraria* Molina Standl.) landraces -
Maatla C. Morapedi
- 1415Hrs** Species richness, diversity, density and spatial distribution of soil seedbanks in the riparian woodland along the Thamalakane River of the Okavango Delta, northern Botswana – Mmusi Mmusi
- 1430Hrs** Assessment of Weeds in flood recession farming in the Okavango Delta - Modise Nthaba
- 1445Hrs** The influence of eutrophication on species composition of riverine plant communities in Eswatini, Southern Africa - Tsheboeng G.
- 1500Hrs** HEALTH BREAK
.....
- 1515Hrs** Forage quantity and quality variability in the functional heterogeneous landscape of the Okavango Delta, Botswana - Tshephang Keemekae
- 1530Hrs** Reacting Rather Than Adapting: Wildlife Policy Responses to Climate Change – Jeremy S. Perkins (Virtual)
- 1550Hrs** [Symposium Organizers’ meeting – housekeeping issues]



Day 2

0830Hrs

Prayer, [Volunteer](#)

0845Hrs

Recap of Day 1

MORNING

Chairperson:

[Dr K. Kashe](#)

0900Hrs

Dynamics of aquatic macroinvertebrates assemblages in the Kwando-Linyanti system, Botswana: A Rapid Analysis - [Belda Mosepele](#)

0915Hrs

The use of aeroponics as a tool in mitigating eutrophication in the Notwane freshwater river system - [Thabo Titus Thomba](#)

0930Hrs

Lethal effects of pesticides to aquatic vertebrates: The case of Three spot tilapia (*Oreochromis- andersonii*) exposure to chlorpyrifos and cypermethrin, and their mixture - [Montshwari Molefe](#)

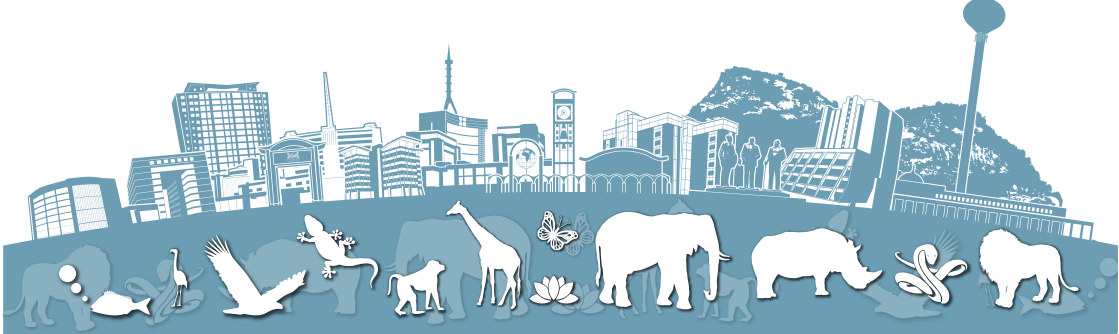
0945Hrs

Reducing livestock-carnivore conflict on rural farms using local livestock guarding dogs - [Morulaganyi Kokole](#)

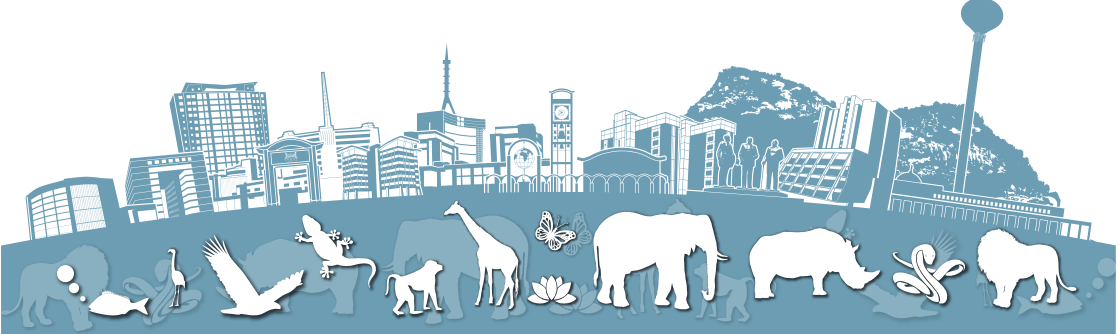
1000Hrs

[Tea Break](#)

[Tea Break](#)



- 1015Hrs** Implications of household economic trade-offs on local community participation in wildlife conservation: Case of the greater Seronga area of the Okavango Delta, Botswana – [Mogae Makonyela](#)
- 1030Hrs** Exploring crop maturity time as a conservation tool for improving resilience to human – elephant conflict: elephant crop raiding - [Tiroyaone A. Matsika](#)
- 1045Hrs** Militarization of conservation and “Shoot to Kill” policies: An analysis of the rights of African States to protect and conserve Wildlife - [Goemeone E. J. Mogomotsi](#) [Virtual]
- 1100Hrs** Protected areas and community based tourism: the effectiveness of current mitigation techniques in human wildlife conflicts - [Patricia K. Mogomotsi](#) [Virtual]
- 1115Hrs** Implications of the “High value low volume” approach in conservation and tourism resources management - [Lesego S. Stone](#) [Virtual]
- 1130Hrs** Levels of Heavy metals and Arsenic in sediment and in *Clarias gariepinus* of Lake Ngami – [Mazrui N.M.](#) [Virtual]
- 1150Hrs** Climate change effect on forest-based livelihoods in Southern Africa: A systematic review – [Hesekia Garekae](#) [Virtual]
- 1210Hrs** Ensuring permeable landscapes in the Kalahari, Botswana: The use of spoor surveys to study wildlife densities, distribution and connectivity - [Marie-Charlotte Gielen](#) [Virtual]
- 1230Hrs** [LUNCH](#)



AFTERNOON

- Chairperson:** [Dr A. Segwagwe](#)
- 1400Hrs** Effects of Elephants, Fire and Climate Variability on Woody Vegetation Bird Habitats in the Chobe National Park, Botswana - [Thabang Setllalekgomo](#) (Virtual)
- 1420Hrs** Enhancing Biodiversity Conservation through environmental awareness in Ngamiland (Chukumuchu village) - [Ratsie M. L.](#) (Virtual)
- 1440Hrs** Dynamics of Human – Wildlife conflicts in Botswana landscapes - [Keoikantse Sianga](#) (Virtual)
- 1500Hrs** Photography: The cornerstone in Biodiversity Conservation - [Edwin N. Morolong](#) (Virtual)
- 15200Hrs** [HEALTH BREAK](#)
- 1540Hrs** [Symposium Organizers' meeting – housekeeping issues]



Day 3

0830Hrs Prayer, [Volunteer](#)

Group photo

Excursions: 1. Big Valley Lodge

- Game Drive
- Lion viewing
- Horse riding
- Zip-line

2. Botswana Meat Commission (BMC)



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- A26. Climate change effect on forest-based livelihoods in Southern Africa: A systematic review – Hesekia Garekae (Virtual)
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SYMPOSIUM ABSTRACTS



Host plant species most preferred for mistletoe colonisation in two urban areas of Botswana

Mpho Granny Batlhophi¹, Tebogo Selebatso¹, Enoch Mdodo Bangomwe Bangomwa², Mpho Rinah Setlalekgomo¹, Joshua Makore³ & Boipuso Legwatagwata¹

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Abstract

Most plant species are not an exception to exploitation by parasitic plants as growth supporting entities. These mistletoes deploy mechanisms to cunningly draw out either water and/or photosynthetic produce against the odds of the host's invasion-defence machinery. The available information regarding parasitic plants falls short of adequately explaining the dynamic facets of mistletoe infestation. This study was carried out to document the host tree species overly preferred for colonisation by mistletoes in two urban areas of Botswana. Additionally, the prevalence rate was estimated where the hosts supported more than one parasitic species. All data were put through statistical analysis at 0.05 level of significance. In sum, four parasitic plants: *Erianthemum virescens*, *Plicosepalus kalachariensis*, *Viscum rotundifolium*, and *Viscum verrucosum* were noted. These appropriated a stem-invasion domain on a total of 17 indigenous tree species from 6 families. The highest mistletoe subsection (47%) was reported on trees belonging to the Fabaceae family, with vulnerability skewed for the Vachellias at a value of 56%. appeared the most dominating where mistletoes coexisted on an individual host tree. However, further studies are necessary to appreciate the interactivity between the contrasting mistletoe species latching on a single host.

Keywords: *boswa, mistletoes, indigenous, invasion, Botswana.*

Investigating changes in abundance and distribution of Wattled Crane (*Bugeranus carunculatus*) in Okavango Delta, Botswana

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Abstract

The International Union for Conservation of Nature rates the Wattled Crane as “vulnerable” and estimates population of mature individuals to range from 6000 to 6300. These have the same conservation status as elephant (*Loxodonta africana*) and lion (*Panthera leo*) but they have a narrow habitat suitability range. In Botswana, the bird is categorized as an endangered species. Therefore, it is of great significance to study the species as a proactive conservation measure for its survival. The Wattled Crane act as key bioindicator of Okavango Delta wetland system status. Due to erratic flows of floodwaters from Angolan highlands the population have been irregularly nomadic in response to water availability. The birds were sighted in previously conducted aerial surveys in the early 2000’s and most recent extensive resurveying within the Okavango Delta. The data was overlaid with changes in landcover over the years to assess extent of relation. The Wattled Crane was found to confine itself in permanently waterlogged areas. There have been mushrooming tourism enterprises within the study area over the years. There is need to further extend monitoring sites to other temporary water catchments in northern Botswana in the summer season for potential use by Wattled Cranes.

Keywords: *Okavango wetland, Wattled Crane, abundance, distribution, landcover*

Mosquito vector diversity and abundance in southern Botswana, in a global context of emerging pathogen transmission.

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Abstract

Mosquito-borne disease transmission poses an ongoing challenge to global public health. Arboviruses are transmitted by vectors in complex transmission cycles between the virus, vertebrate host, and the vector. It is therefore critical to improve our understanding on the present abundance and distribution of major vectors that determine human populations at risk for the diseases transmitted in order to prepare for potential arbovirus outbreaks. Climate change has affected mosquito abundance and their seasonal survival in many areas of Botswana, greatly influencing the spread of vector-borne diseases. Mosquito sampling was performed in Gaborone and the surrounding areas in the southern part of Botswana that also included border posts. *Methods:* Different stages of mosquitoes were sampled from each location, reared to adult stage and identified. Identification was both morphologically and by molecular analysis. Out of the 5177 mosquitoes collected and identified, 88.3% accounted for *Culex* species while *Aedes aegypti* and *Anopheles species* accounted for 11.5% and 0.2% respectively. These findings, document the mosquito species diversity and abundance as well as presenting an entomological baseline data that will give an insight in the understanding of a vectorial pattern and an estimation of arboviral risks that mosquitoes may pose in future.

Keywords: *Aedes aegypti*, *Culex spp*, *ovi-trap*, *surveillance*

Status and Occurrence of Fruit Fly Species (Diptera: Tephritidae) in the Western Region of Botswana

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Abstract

The sustainable management of fruit flies of economic and quarantine importance is mainly reliant upon accurate detection of the fruit fly species. A seventeen-month survey to detect fruit flies using both male and female pheromone lure trapping method was carried out from November 2016 to April 2018. A total of seventy-five parapheromone lure-baited Chempac traps and five types of lures (Pumpkin Fruit Fly Pherolure (PFF), 3-Component Pherolure (3C), TrimedLure Pherolure (TML), Enriched Ginger Oil Pherolure (EGO) and Methyl Eugenol Pherolure (ME), with Dichlorvos 20% W/W (DDVP) strip (insecticide) were used. The traps were placed at random in Kang (10), Central Kalahari Game Reserve (CKGR- viaTsau gate) (35) and Maun (30). The geographical occurrence of the fruit fly species was established using a Garmin etrex Global Positioning System receiver and mapped onto Geographic Information System (GIS). Twelve species of Tephritid fruit flies which includes eleven indigenous species (Afrotropical origin) and one exotic species (Asian origin) were detected in the localities of Kang, CKGR and Maun. The main species of fruit fly caught in the ME-lure trap were *Bactrocera dorsalis* (quarantine importance). The Mediterranean fruit fly (*Ceratitis capitata*) was detected in the Enriched Ginger Oil Pherolure (EGO) trap. Eight species belong to the *Dacus* genus and were abundant, whereas the other species were less prevalent.

Keywords: trapping, fruit fly, species, para pheromone lure, Tephritidae, detection

Beyond Power Supply: Prevalence and Distribution of Bird nests along the Palapye-Foley Transmission Powerline, Botswana

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Abstract

Electricity is an essential resource to the world's economic development since most if not all industries are heavily dependent on it as a source of power. Hence, electrical infrastructures are increasingly widespread across the world in order to reach demand at various load centres. Beyond power supply, the infrastructure can be beneficial and detrimental to biodiversity, especially avian species. However, there is inadequate empirical evidence on birds-powerline interaction in Botswana. It is against this backdrop, that this study assessed the correlates of occurrence and frequency of occurrence birds' nests on the Palapye-Foley transmission power line infrastructure. Two-hundred and sixty-one (261) and seventy-nine (79) pylons were sampled from Morupule-Serule substation and Serule substation to Foley village respectively along a total transect distance of approximately 120 km. Whenever bird's nest were encountered, the birds species, nests frequency, sizes and placement of nests on pylon structures were recorded. General Linear Model was used to assess correlates of distribution of birds' nests. A total of 134 nests were encountered on 69 of the 261 pylons surveyed. Three avian species nests were associated with the Morupule-Foley transmission powerline, namely red-billed buffalo weaver (*Bubalornis niger*), lesser masked weaver (*Ploceus intermedius*) and cut-throat finch (*Amadina fasciata*). The findings show that hydrology and vegetation types were significant predictors of nest frequency. Nest size was significantly different across the pylons. The study provided key insights to infrastructure managers to mitigate human-wildlife conflicts as well as for conservation purposes to reduce bird mortality through installation of nesting platforms on structures located in favourable habitats for target species.

Keywords: *Bird nesting, frequency, electricity pylons, powerlines, mitigation, main drivers.*

Natural infections of Bottle Gourd (*Lagenaria siceraria* Molina Standl.) landraces by three diseases at the Glen valley area, Botswana

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Abstract

Pests can cause a drastic reduction of yield and even affect the marketability of bottle gourd (*Lagenaria siceraria* Molina Standl). Crops that are able to withstand infections by pathogens are desirable to farmers as they reduce the cost of production which would have otherwise been escalated by the use of chemicals for control of the diseases. The objective of the study was to document natural pest occurrence (insects and diseases) on bottle gourd landraces grown at Sebele-Glen valley area in Botswana. Five Bottle gourd accessions, MBP025, MMB244, MBP026, MBP005, and MBP052 were acquired through random selection from the National Plant Genetic Resources Centre (NPGRC) Gene Bank (Sebele, Botswana) for the study. Plants were grown to observe variations in morphological characteristics. Amongst the many morphological characters observed, the natural occurrence of plant diseases were also recorded. Leaves that displayed disease symptoms were collected in sample bags for laboratory evaluation at the BUAN Plant Pathology Laboratory. Confirmation of the disease and causal agent was verified using standard laboratory analysis methods. The leaf samples with characteristic virus infection were tested for three viruses namely: Watermelon mosaic virus (WMV), Zucchini yellow mosaic virus (ZYMV) and Squash mosaic virus (SqMV) using double antibody sandwich-enzyme linked immune-sorbent assay (DAS-ELISA) with specific antibodies against each virus. Powdery mildew fungal disease was

observed with high disease incidence of sixty percent. Virus detection with DAS-ELISA confirmed the presence of two viruses being ZYMV and WMV, all these viruses are in the genus Potyvirus and they are naturally transmitted by many species of aphids in non-persistent manner. Bottle gourd accessions MBP026 and MBP005 were moderately tolerant to (ZYMV); MMB244 showed mixed infection of ZYMV and WMV which consequently reduced its yield. SqMV was not detected in the tested plant samples. The occurrence of a powdery mildew disease and two virus pathogens ZYMV and WMV on *Lagenaria siceraria* is being reported for the first time in Botswana. The current findings add to the knowledge of the diversity of pathogens that affect cucurbits worldwide, more especially for Botswana where documentation of disease causing pathogens is less documented. Further analysis of pathogens using molecular techniques is highly recommended in order to help in selection for disease resistance within the cucurbits.

Keywords: *landraces, Bottle gourd, disease, powdery mildew and virus*

A preliminary assessment of the distribution of alien invasive plant species in Chobe district, northern Botswana

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Abstract

Invasive alien species (IAS) are notorious for biodiversity loss and irreversible alteration of ecosystem composition and functioning. Additionally, they can have significant impact on local people that depend on ecosystem services for their livelihoods. This paper provides a pre-liminary list of alien invasive plant species in Chobe district, northern Botswana. The list was based on broad-scale survey in arable fields, residential areas, roadsides and other disturbed sites. The survey was conducted from Pandamatenga to Parakarungu. The results showed that arable farms were dominated by *Amaranthus hybridus*, *Acanthospermum hispidum* and *Cenchrus biflorus*. However, *C. biflorus* was found to be a problem in farms with sandy soils. Residential areas were dominated by alien invasive tree species namely, *Leucanea leucocephala*, *Jatropha curcas* and *Ailanthus altissima*, suggesting that these trees were intentionally introduced as ornamentals and shade trees. Roadsides and other disturbed sites were mostly dominated by *A. hispidum*, *Ricinus communis*, *Datura ferox*, *Verbesina encelioides* and *Xanthium strumarium*. The dominance of most of these invasive plants raise a concern over their threat to biodiversity and food security. They pose a threat to ecosystem functioning and ecosystem services. In cropped areas, they reduce crop yields and aggravate food shortage. Steps need to be taken to reduce these impacts. The most important of these is the introduction of management and control programmes to contain and eliminate invasive plants in their area of introduction. The study recommends consultation with the local community to remove invasive tree species from their homesteads and replace them with indigenous species that will provide same ecosystem services.

Keywords: *Invasive alien plants, distribution, biodiversity, ecosystem, Chobe district*

A Review of Fish Parasite Diversity in Botswana

Maxwell Barson

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Abstract

Despite being dry and landlocked, Botswana freshwaters have several fish species, among which catfish *Clarias gariepinus*, tigerfish *Hydrocynus vittatus*, tilapias (*Oreochromis mossambicus* and *Coptodon rendalli*) represent the most common indigenous species that supply food protein to the local populace. Three-spot tilapia *Oreochromis andersonii* and the invasive Nile tilapia *Oreochromis niloticus* are commonly being farmed in aquaculture. This paper reviews the current biodiversity of fish parasites in Botswana, assessing their potential threats to aquaculture and biodiversity. Out of 73 fish species in the Okavango, Chobe and Limpopo river systems, 60 parasite species have been recorded, with 50 of them from an extensive parasitological expedition to the Okavango Delta conducted by a team of South African professors and students between 1999-2003. The only other fish pathogen that has received international attention is the water mold *Aphanomyces invadans* that causes epizootic ulcerative syndrome (EUS), which killed millions of fish in the Chobe-Zambezi system in 2006-7 and for which active surveillance is still being conducted by the Botswana Department of Veterinary Services. Fish parasitological records from the rest of Botswana are virtually non-existent although a current study by the University of Botswana is seeking to plug this gap. This review will contribute to the growing aquaculture industry in Botswana in terms of parasitic infection and disease surveillance data, contribution to conservation, faunal and genetic biodiversity of Botswana, fish health status and its implication on environmental and public health. On a wider scale the study will contribute towards the national aquatic animal health pathogen list that informs national and regional fisheries and aquaculture policy-making, especially towards prevention of transboundary fish disease transmissions.

Keywords: *Fish parasite, biodiversity, aquaculture, surveillance, Botswana*

A quality review of biodiversity inputs for tourism EIAs in Botswana's Okavango Delta

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Abstract

Environmental Impact Assessment (EIA) is a practise intended to enable sustainable development through safeguarding of resources in project areas. During EIA, biodiversity inputs inform the conscious consideration of ecological impact of/on proposed developments. Biodiversity inputs include baseline information, impact prediction, and monitoring arrangements. Legislated in nearly 200 countries, EIA has been mandatory in Botswana since 2005. One area of key international biodiversity value is the Okavango Delta, a wetland of international importance and a World Heritage Site. The Delta forms, by far, the core economic asset of the Nhabe District; being nature-based tourism. The relatively pristine Delta leads the country by a wide margin in the number of biodiversity-related research being conducted. Furthermore, tourism lodges in the area are constantly being developed here, seeking to harness the opportunity of the biodiversity asset. Acknowledging the cumulative impact of lodge development on natural resources, it is expected that EIA conducted in the Okavango over the past decade would reflect substantial research uptake, in addition to project-specific specialist input. A leading method of determining EIA report quality is the use of so-called review packages. An adapted Lee and Colley review package was therefore used to determine the quality of biodiversity inputs for 33 EIAs for tourism lodges in the Okavango area. The review covered reports produced between 2011 and 2020. Over half of the reports were found to have unsatisfactory biodiversity input as baselines were frequently vague and did not enable follow up impact monitoring. Impact prediction was also not transparent, compromising validity. Acknowledging that satisfactory biodiversity input informs sustainable ecological management, it hence follows that the status quo risks eroding the very resource driving the district's livelihood. It is key to appraise the practitioner community of this inadequacy to enable the realisation of the true value of EIA, and ultimately sustainable development.

Keywords: *EIA, Okavango, EA, tourism, Nhabé*

Morphological Variability in Botswana Bottle Gourd (*Lagenaria siceraria* Molina Standl.) Landraces

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Abstract

Bottle gourd (*Lagenaria Siceraria* Molina Standl.) landraces are usually grown in Botswana under subsistence farming. Morphological characterization of the landraces is important to identify promising landraces for breeding, conservation and commercial farming. The main objective of the study was to characterise the bottle gourd landraces based on qualitative and quantitative traits. Five accessions, MBP025, MMB244, MBP026, MBP005, MBP052 were acquired through random selection from the National Plant Genetic Resources Centre (NPGRC) Gene Bank for the study. The study was conducted at Glen Valley farms, Gaborone in a Randomised Complete Block Design. Data was collected using the European Cooperative Programme for Plant Genetic Resource (ECPGR) descriptors for cucurbits. The results showed significant differences in fruit characteristics, also significant differences in the quantitative traits were noted except for peduncle length. Cluster analysis separated the clusters into three groups. Cluster 2 was the major cluster based on 50% germination, internode length, vine length, fruit colour, number of marketable fruits and peduncle length. Three principal components which were mostly fruit related accounted for 84.9% of the variation. The yield positively correlated with mostly quantitative characteristics. Landrace MBP026 exhibited mostly desirable characteristics in the study, therefore, it may be recommended for breeding and/or multiplication while MMB244 which was the least performing landrace could be improved to harness some of the desirable characteristics displayed. Molecular characterisation of bottle gourd landraces should also be undertaken to lay foundation for other studies such as genetic improvement and agronomic evaluation to exploit potential of the crop.

Species richness, diversity, density and spatial distribution of soil seed banks in the riparian woodland along the Thamalakane River of the Okavango Delta, northern Botswana

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Abstract

Soil seed banks serve as reservoir of seeds for subsequent regeneration of plants. Soil seed banks were investigated along the Thamalakane Riparian Woodlands (hereafter referred to as TRWs) of the Okavango Delta, northern Botswana, from January-July 2015 and January-July 2016. The study aimed at examining species richness and diversity, determining densities, assessing the spatial distribution of seeds in the soil and comparing the similarity in species composition between the standing vegetation and soil seed bank flora. The vegetation was sampled in 71 plots (20 × 50 m) and soil samples were collected from 568 subplots. Agglomerative Hierarchical cluster analysis was used to determine soil seed bank communities. Indicator species analysis was used to calculate indicator values for species in each community of germinated seeds and across different soil layers. Multi-response permutation procedures (MRPP) were used to compare similarity in soil seed bank composition. Bray-Curtis ordination was used to infer spatial relationships of soil layers in terms of soil seed bank composition. A total of 109 plant species were identified in the litter and top 9 cm soil layers with a total density of 2,101 seeds m⁻². Herbs, grasses, sedges and woody plants were represented by 68, 19, nine and 13 species, respectively, in 30 families and 87 genera. The overall total diversity and evenness of the soil seed bank in the TRWs was 3.25 and 0.69, respectively. Four plant communities were identified from the soil seed bank, namely *Setaria verticilata*-*Amaranthus hybridus*, *Acanthospermum hispidum*-*Setaria sagittifolia*, *Digitaria eriantha*-*Eclipta prostrata* and *Cyperus*

longus-Fimbristylis dichotoma. Bray-Curtis ordination showed that there was overlap between these communities in terms of seed bank composition. However, MRPP analysis showed that there was significant ($P < 0.05$) separation between germinated soil seed bank communities. The overall horizontal distribution of seeds varied among sampling quadrats while the vertical distribution of seeds exhibited the highest densities occurring in the upper 3 cm of the soil and gradually decreasing densities with increasing depth. Relatively high densities also occurred in the litter layer. There were large differences in depth distribution between species, suggesting differences in seed longevity. The similarity in species composition between the soil seed flora and standing vegetation was low (27%). The results demonstrated that many species in TRWs store quantities of seeds in the soil. The fact that most of the woody species do not accumulate more seeds in the soil suggests that their regeneration from seeds would be unlikely if mature individuals disappeared (die or are harvested). Because of its diverse seed banks, the herbaceous flora would have a better chance of re-establishing in the events of anthropogenic or natural disturbances. Therefore, the future of the TRW woody flora seems to depend on the successful conservation of the standing vegetation.

Keywords: *Diversity; Evenness, Germination; Soil seed density; Spatial seed distribution; Species richness*

Assessment of weeds in flood recession farming, in the Okavango Delta

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Abstract

Flood recession farming, locally known as molapo farming, is an important livelihood activity for the subsistence farming community around the Okavango Delta. The study was aimed to determine the dominant and most abundant weed species in different types of flood recession farming practiced in the peripheral settlements of Shorobe, Makalamabedi and Lake Ngami.

Vegetation sampling was conducted from March to April 2016 in 36 fields under saucer-shaped, channel type and fields situated in the flats of Lake Ngami. Sampling was done in 1m² quadrats placed 10 m apart along a line transect. The Simpson's dominance index for individual species were determined using Paleontological Statistics (PAST) version 3.12. Rank/abundance plot was used to plot species abundance data to rank weeds species for each flood recession farming. It type was done on PC ORD.

The most abundant broad leaf weed in saucer shaped flood recession type was *Hibiscus cannabinus* L. with a mean species abundance of 0.364 ± 0.392 followed by *Sida cordifolia* L. with mean species abundance of 0.340 ± 0.334 , and under channel type *Corchorus tridens* L. was the most abundant species with mean species abundance of 0.6135 ± 0.4365 followed by *Ipomea sinensis* L. with a mean of 0.3431 ± 0.3595 and a dominance index of 0.8328 while in lake flats *Ipomea cotinifolia* (L.) Roem & Schult was ranked the most abundant weed with mean rank abundance of 0.400 ± 0.409 and $D = 0.8368$. *Digitaria debilis* (Desf) and *Cynodon dactylon* were the most common and abundant grass weeds under all types of

flood recession farming. *Bulbostylis hispidula* (Vahl) R.W. Haines was the most abundant sedge in under saucer-shaped and channel type recording, a mean of 0.289 ± 0.386 and 0.401 ± 0.516 respectively and *Cyperus compressus* L. was the most abundant and most dominant sedge in Lake flats with a mean of 0.667 ± 0.516 . Types of flood recession farming support weeds species that are not commonly found under dry land farming most of which are grasses like *Digitaria debilis* *Leptocarydion vulpiastrum*, *Panicum repens* and sedges like *Cyperus compressus*. However, under flood recession farming, there were some grass and broad leaf weeds which were wetland species that tolerate some dry periods or seasonal flood plains.

Keywords: Flood recession farming, Saucer shaped type, Species dominance, Rank abundance.

The influence of eutrophication on species composition of riverine plant communities in Eswatini, Southern Africa

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Abstract

Understanding the impact of nutrient enrichment on plant species diversity can help in informing land use policies to ensure sustainable utilization of river ecosystems. This study assessed the effect of eutrophication on plant species composition along Usutu River in Eswatini. Plant species were identified and abundance estimated in 1m × 1m quadrats placed along 50m transects. The transects (4 per site) were placed in No-nutrients, Low-nutrients and High-nutrients sites. Agglomerative Hierarchical cluster analysis was used to classify plant communities. Indicator species analysis was used to calculate indicator values for each species. Multi-response permutation procedures were used to compare species composition between the communities. ANOVA and Tukey post-hoc test were used to test for statistical significant difference between sites. Three communities identified were: *Pteridium aquilinum*-*Athyrium filix-femina* (No-nutrients), *Pycreus macrostachyos*-*Cyperus longus* (High-nutrients) and *Paspalum urvillei*-*Aristida scuirus* (Low-nutrients). These communities differed significantly ($p < 0.05$) in species composition. Species that were common in all the sites were *Typha capensis*, *Pteridium aquilinum*, *Athyrium filix-femina*, *Persicaria limbata*, *Schoenoplectus corymbosus* and *Oxalis corniculata*. There was no significant difference ($df=2$, $F=1.549$, $p=0.218$) in mean cover of *Typha capensis* between the sites. In *Pteridium aquilinum* mean cover was significantly ($p=0.036$) higher in No-Nutrients site than in High-Nutrients site. The No-Nutrients site did not differ significantly ($p=0.069$) from the Low-nutrients site. The same trend was observed between the Low-Nutrients and High-Nutrients sites ($p=0.37$). In *Athyrium filix-femina*, mean cover was significantly higher in the No-Nutrients

site than in Low-Nutrients ($p=0.006$) and High-Nutrients ($p=0.009$) sites. *Schoenoplectus corymbosus* ($df=2$, $F=3.177$, $p=0.05$), *Persicaria limbata* ($df=2$, $F=0.8209$) and *Oxalis corniculata* ($df=2$, $F=0.0323$, $p=0.9197$) did not show any significant variation in mean cover between the sites. Plant species richness and diversity were significantly ($p<0.05$) higher in High-nutrients site than in Non-nutrients and Low-nutrients sites. Density was significantly ($p<0.05$) higher in Non-nutrients site than in High-nutrients site. This study calls for mitigation of eutrophication in Usutu River in order to conserve its plant diversity.

Keywords: *Communities, Conservation, Enrichment, Nutrients and Vegetation*

Forage quantity and quality variability in the functional heterogeneous landscape of the Okavango delta, Botswana

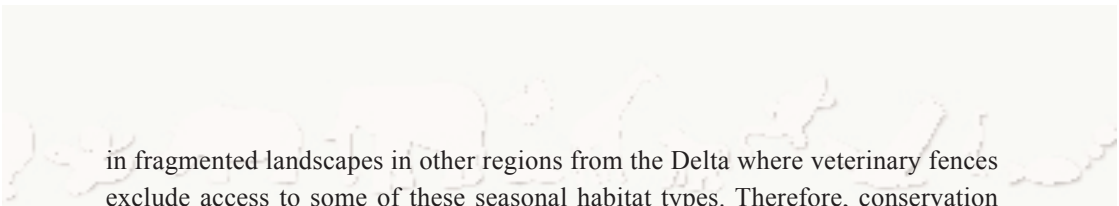
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Abstract

Many rangelands are characterised by strong seasonal and intra-annual forage quantity and quality variability and these spatial and temporal distribution of the quantity and quality of forage across landscapes is a major determinant of adaptive foraging movements by herbivores across the annual cycle. Livestock and wildlife can adapt to this variability by accessing functional heterogeneity of resources, but landscapes fragmentation reduces access to functional heterogeneity which brings along decreased intake, weight loss, reduced reproductive performance and increased mortality during drought. With that, the study determined changes in the quantity and quality in different habitats and across the seasons. A three main season was chosen for sampling and five main habitats were identified, woodlands and wetlands, and vegetation was sampled for nutrient content, greenness and biomass. The results showed that functional resources heterogeneity is provided by various woodlands and wetlands habitats. Woodland habitats provide higher protein, calcium, magnesium, phosphorus, and potassium during wet season while shallow floodplains provide the highest sodium content. The deep floodplains support the highest biomass annually and provide better protein and biomass during dry season. It is thus important for cattle to graze in the woodlands and shallow floodplains during wet season, and graze in the deep floodplains during dry season. The availability of all these habitat types for cattle in the Eretsha region results in cattle having access to excellent functional habitat heterogeneity, which should enable them to adapt much better to seasonal and interannual variation than cattle



in fragmented landscapes in other regions from the Delta where veterinary fences exclude access to some of these seasonal habitat types. Therefore, conservation strategy is disenfranchising communities and restricting wildlife access to functional heterogeneity.

Keywords: *forage quantity and quality; functional heterogeneity; key resources; landscape fragmentation; seasonal variation.*

Reacting Rather Than Adapting: Wildlife Policy Responses to Climate Change

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Abstract

There is currently a major disconnect between the realities of climate change and the policy responses to it in the wildlife sector. Short term reactive management responses such as the provision of artificial water points for wildlife, suppression of active wildfires and a whole host of human wildlife conflict mitigation measures (for example predator proof kraals and the use of deterrents such as red chilli peppers, bees etc.) will simply not solve the medium to longer term challenges posed by climate change. Indeed, on the contrary, many such reactive measures seem likely to make biodiversity loss and ecosystem disruption worse rather better as southern Africa's climate becomes hotter and drier. The fundamental disconnect is that the spatial and temporal scale of management is both too localised and too short term, respectively. This is perhaps understandable as the solution lies in Policy responses that necessitate a major deviation from the existing status quo. Co-existence between local communities, wildlife, livestock owners and agriculturalists is going to be necessary over strategic swathes of the country and region, in turn requiring transformative economic and social change in which natural resources are valued, conserved and used to directly benefit local communities. The rapid rate of the predicted changes in temperature means that ecosystems will have little time to adapt, making it essential that species are able to track their preferred habitat if extinction risk is to be minimised. Well managed, protected but isolated Protected Areas or Game Reserves will simply not allow species populations to undertake the required range extensions or shifts. By identifying key strategic areas and the main Policy measures that need to be taken this paper provides an opportunity to adapt rather than react to climate change and assist in averting the worst effects of the Sixth Great Mass Extinction.

Keywords: *Climate change, adaptive management*

Dynamics of aquatic macroinvertebrates assemblages in the Kwando-Linyanti System, Botswana: A Rapid Analysis.

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Abstract

Freshwater macroinvertebrates biodiversity forms the basis of primary production in aquatic systems. Their diversity, richness and spatial distribution can be used as proxy indicators of ecological dynamics and ecosystem health. The aquatic macroinvertebrate biodiversity of the Kwando-Linyanti River system in northern Botswana remains relatively unstudied compared to the Okavango Delta. This study serves as baseline for future ecological monitoring of this aquatic system. 25 sites were sampled; data on aquatic macroinvertebrates and water quality parameters (pH, DO, Cond, Temp and Depth) were collected using standard methods. These datasets were analyzed using multivariate techniques in PRIMER v6, with significance level set at 95% confidence. 5301 specimens collected composed of 16 orders and 58 families in the study area. Chironomidae and Atyidae were the most dominant families respectively while Potomonautidae, Simuliidae, Tipulidae, Platycnemidae and Hydropsychidae were relatively rare. Some upstream habitats on the Kwando River had the highest abundance of macroinvertebrates communities while some floodplain habitats in the same river system had relatively lower abundances. It is envisaged that this study will provide a framework to develop long term monitoring of aquatic biodiversity in the Kwando-Linyanti-Chobe system.

Keywords: *Freshwater macroinvertebrates, diversity, richness*

The use of Aeroponics as a tool in mitigating Eutrophication in the Notwane Freshwater River system

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Abstract

Ecological restoration and bioremediation in Botswana are the hottest issues as far as conventional farming is concerned. Nitrogenous and phosphatic fertilizers have been used for the longest period of time in the farm fields of Oodi, along the Notwane River, with the aim to increase agricultural yields and maximize on the returns (Markus, 1999). (Hill, 1997) stated that agrochemicals lead to the oversupply of nutrients in aquatic systems following agricultural runoff, resulting in algal bloom with promotion of cyanobacteria. As a result of eutrophication, the cyanobacteria uses up the available dissolved oxygen to decompose phytoplanktonic material, suffocating aquatic biome to death. The research was motivated by recognition of the algal bloom tarnishing the ecological well-being of the aquatic ecosystem through bad smell and high turbidity. It was a way of bringing up sustainable development and innovative agricultural technologies to uphold the SDGs number 6, 14 and 15, and defend ecological stability, paving way for unsustainable green revolution and innovative urban agriculture, and green revolution approach towards conservation, environmental sustainability and food security. Reduction of fertilizers from the agricultural fields is a vital aspect in the industry of arable farming through aeroponics and tracking of agricultural runoff by analysing soil samples collected from the farms located at 24°33'49"S 26°01'27"E, checking for phosphates and nitrates levels using phosphates and nitrates analysis test, Remote sensing application through Globe observer and ArcGIS 10.7 for mapping potential geographical threats contributing to nutrient loads. Aeroponics (nitrates, phosphates and nitrates-nitrogen) concentrations are at 0ppm. This reconceptualises the ecosystem and natural resources with manipulations of pedosphere and hydrosphere characters positively to restore the ecosystem.

Keywords: *Aeroponics, Conservation, Environmental sustainability, Eutrophication, Innovative urban agriculture.*

Militarisation of Conservation and “Shoot to Kill” Policies: An analysis of the Rights of African States to Protect and Conserve Wildlife

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Abstract

This chapter discusses militarisation as a viable policy tool for wildlife conservation in Africa. It places the militarisation of wildlife law enforcement and conservation within the legitimate preservation of the sovereignty of states. The chapter adopts traditional legal research methodology to investigate the rights of states to pursue, target and kill poachers who are often armed with weapons of war. It characterizes poachers as armed belligerents who can be equated to terrorists. Therefore, the chapter argues that international humanitarian law (law of armed) can be lawfully used by nation states to enforce international wildlife law. The chapter concludes that states have a right to adopt legal framework for the adoption and execution of militarisation of conservation. It further concludes that the shoot-to-kill approach to conservation can be an effective part of the wider approach to effectively combat poaching and protect wildlife species for the benefit of future generations.

Keywords: *militarisation of conservation, shoot-to-kill, Southern Africa, international humanitarian law, anti-poaching, law of armed combat*

Protected areas and community-based tourism: the effectiveness of current mitigation techniques in human wildlife conflicts

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Abstract

Human–wildlife conflicts are not only one of the most critical threats to biodiversity conservation but also to livelihoods of communities living adjacent to protected areas in southern Africa. The conflict mitigation strategies range from lethal to non-lethal. However, there is a dearth of studies on the efficacy of these interventions in southern Africa. This chapter uses a systematic literature review approach to identify, select, and critically appraise literature sources to determine factors influencing the choice of human-wildlife conflict mitigation strategies in southern Africa and discuss lethal and non-lethal approaches to mitigating human-wildlife conflicts. The findings reveal that although there are various approaches to mitigating human-wildlife conflicts, there is no single approach that can adequately deter predators and crop-raiders effectively. Therefore, governments and other stakeholders should identify and embrace integrated interventions with an understanding of people’s expectations, realities, and attitudes to ensure efficacy.

Keywords: *Protected areas; human-wildlife conflicts; sustainable tourism; conservation; Africa*

Implications of the “High-value, Low-Volume” approach in conservation and tourism resources management

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Abstract

With the promotion of the High-value, Low-volume tourism strategy (HVLV), Botswana’s tourism industry continues to record steady growth in an ever-increasing competitive market. However, indications are that the HVLV tourism strategy has changed Botswana’s tourism landscape, resulting in a domination by the international tourism market on the consumption of the country’s nature-based tourism offerings compared to the domestic market. This imbalance has led to an unreliable and unsustainable tourism development approach. Using data from previous studies carried out by the authors and secondary data sources, this chapter, adopts a qualitative study design and uses sustainable tourism development underpinnings to analyse the implications of the HVLV tourism strategy on conservation and tourism resources management. Results indicate that although the HVLV tourism strategy has contributed to community livelihoods and the conservation of tourism resources, it has also yielded unintended consequences by stifling and limiting the domestic market from consuming Botswana’s most sought-after destinations. Furthermore, the HVLV tourism strategy has contributed to enclave tourism development. While the call for Low-Volume takes care of resources’ conservation, the High-Value part excludes locals, compromising principles of sustainability; social equity, and justice. Due to the unintended repercussions of the HVLV strategy, the chapter proposes the promotion of domestic tourism to nature-based tourism sites during the low season to cater for seasonal variations created by international tourism. However, this should be within acceptable limits to avoid destroying the tourism product the country is renowned for. Furthermore, the country should promote tourism to other less popular areas to spread the benefits of tourism to other parts of the country

Keywords: *High-value, Low-Volume, sustainable tourism development, domestic tourism, international tourism, conservation and tourism resources*

Lethal effects of pesticides to aquatic vertebrates: The case of Threespot tilapia (*Oreochromis andersonii*) exposure to chlorpyrifos and cypermethrin, and their mixture

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Abstract

Pesticides have become an integrated component of intensive agriculture to fight pests and hence increase agricultural productivity. However, pesticides ultimately find their way into aquatic environments. In aquatic environments, pesticides do not only appear as individual toxicants but rather as mixtures of complex contaminant compounds, jointly detected at a time. This has raised concerns about their impacts on non-target aquatic organisms such as fish because of its importance to human beings. As an expression of the degree of toxicity of chemicals to aquatic organisms, this study determined the 96-hour acute toxicity (96-hour LC50) effects of chlorpyrifos (organophosphorous pesticide) and cypermethrin (pyrethroid pesticide) individually, and their mixture to juvenile threespot tilapia (*O. andersonii*). The experiments were conducted according to Organization for Economic Co-operation and Development (OECD) guidelines 203. Under semi-static laboratory conditions, healthy live juvenile *O. andersonii* (average length 6 ± 0.6 cm, average weight 3.2 ± 0.32 g) of both sexes were randomly exposed for 96 hours to different logarithmic concentrations of either chlorpyrifos

or cypermethrin and their mixture to investigate single and joint toxicity (1:1 binary mixtures) of the chemicals respectively. The probit method and Additive Index (AI) were used to quantify the effect of the pesticides. Individually, chlorpyrifos and cypermethrin proved super toxic to *O. andersonii* with their 96-hour LC50 (95% confidence limits) calculated at 55.187 μ g/L (44.207 - 68.895 μ g/L) and 11.692 μ g/L (9.780 - 13.978) respectively. The 96 hour acute toxicity of the chemicals to the test organism were significant ($P < 0.05$). However, at 96 hours, the joint mixture toxicity reflected a neutralized mixture of cypermethrin and chlorpyrifos on exposure to *O. andersonii* with biological activity (S) of 1.02 giving an antagonistic effect (AI=-0.01659). Our results showed that toxic effects of chlorpyrifos and cypermethrin and their mixture may negatively impact aquatic biodiversity with behavioral alterations including loss of equilibrium, abnormal swimming and abnormal ventilatory functions.

Keywords: *Acute toxicity (LC50), joint toxicity, chlorpyrifos, cypermethrin, Threespot tilapia (Oreochromis andersonii)*

Reducing livestock-carnivore conflict on rural farms using local livestock guarding dogs

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Abstract

Livestock depredation can be devastating to both farmers and the species considered responsible if they are subsequently persecuted. Many proposed conflict solutions are limited in their uptake because they may be short-term, localised, expensive or species-specific. Livestock guarding dogs have been a successful solution in many parts of the world, however recommended imported breeds are generally expensive or inaccessible to many rural farmers. In this study, we report on a program placing local Tswana dogs with farmers in Botswana as a tool to reduce livestock loss. Seventy-five farmers who experienced high conflict from carnivores in both rangelands and wildlife areas were selected to receive a Tswana puppy. Puppies were monitored regularly to determine their performance, survival and owner attitudes toward wildlife. From initial baseline reports of goat losses before farmers received a puppy, loss declined by at least 85% over the following three years. Farmers were very satisfied with the performance of their livestock guarding dog and attitudes toward protection and tolerance of wildlife improved after one year of receiving a puppy. Our study suggests locally bred Tswana dogs are an effective solution for livestock at risk to depredation, particularly for rural farmers and development of community-led programs can be further used to reduce conflict.

Keywords: *conservation, depredation, human-wildlife conflict, mitigation, rangelands*

Implications of household economic trade-offs on local community participation in wildlife conservation: Case of the greater Seronga area of the Okavango Delta, Botswana

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Abstract

People living alongside wildlife are vulnerable to livelihoods shocks due to their dependence on depleting resources, growing populations and minimal means of risk management. Households in such areas are poor due to recurring livelihoods' shocks including livestock predation and crop damages by wildlife. Rural communities in northern Botswana are economically and socially deprived, and their participation in wildlife conservation around resources use, value and benefit overtime. In promoting sustainable coexistence of humans and wildlife, households endure consequences of management decisions without sufficient relief to sustain their livelihoods. It is important to incorporate community participation into conservation tools as a pertinent approach bringing mutual benefit to both biodiversity and communities. Thus, the study assessed the influence of household economic trade-offs on community participation in wildlife conservation initiatives in the Greater Seronga Area of the Okavango Delta, Botswana. A cross-sectional passive-analytical mixed-methods approach was used. Household survey was used to collect primary data from 248 household heads selected by simple random sampling from five villages in the area. Data were analysed using Spearman's rho correlation coefficient (ρ) test, Pearson Chi-Square (χ^2) test, thematic analysis, and key-word-in-context. Communities in the study area suffered costs such as crop damages and livestock predation by wildlife. Compared to benefits gained,

80% of surveyed households did not benefit economically from wildlife conservation initiatives. The Chi-square test ($\chi^2=53.850$ and p-value of 0.000) yielded a significant association between benefits and participation in wildlife management. Where costs surpassed benefits, communities were less inclined to participate in wildlife conservation. A clear link between the kind of benefits received and the conserved resource generating the benefits should be established.

Keywords: *Benefits, community participation, costs, households', Okavango Delta, wildlife conservation*

Exploring crop maturity times as a conservation tool for improving resilience to human-elephant conflict: elephant crop-raiding

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Abstract

Human-wildlife conflict is a major challenge towards species conservation in Botswana. Smallholder farmers around the Okavango delta grappled with food insecurity and other negative impacts of elephant crop-raiding. This loss of a basic need such as food resulting from elephant raiding potentially worsen the hostility towards elephants and consequently thwart the intentions of conservation or coexisting with such species in this area. Although many studies have identified the relationship between crop-raiding and climatic factors, especially rainfall, little attention was paid to aligning cropping duration to high rainfall, thus minimizing incidences of conflict emanating from crop-raiding. This study, therefore, proposed an avoidance strategy involving the prevention of crop raids via early harvest rather than the symptomatic counter treatment of elephant raiding. The study investigated how the crops maturity cycle influences the farmers' vulnerability to crop-raiding and food loss. The study used both early and late maturing cultivars of sorghum, maize and cowpea. The experiment was replicated three times and laid out in four different villages in the eastern Okavango region. The findings revealed that the early maturing varieties resulted in increased yield, which significantly benefited the farmer compared to late-maturing varieties sorghum ($P=0.04$) and cowpea ($P=0.02$). However, the latter was contradictory for the maize varieties ($P=0.08$). The type of crop on its own ($P=0.0001$), and the combination of crop*maturity*location ($P=0.01$) impacted the yield significantly. The presence of elephants around crop fields significantly increased as weeks advanced. The increase in the presence of elephants and consequent increase in



crop-raiding were statistically correlated to rainfall ($P=0.00$). Therefore, early maturing varieties allowed harvesting at a time when elephants were not frequently present near farms. This timing of harvest reduces the vulnerability of crops to the debilitating elephant raiding. Therefore, mitigations benefiting both farmers and elephants form an essential component of co-existence and significantly influence the success of many conservation projects.

Keywords: *conflict, resilience, food security, co-existence*

Levels of Heavy Metals and Arsenic in Sediment and in *Clarias Gariepinus* of Lake Ngami

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Abstract

Over the last several decades, there has been a rapid increase in deforestation, agricultural activities and fossil fuel use. Subsequently, the amount of trace elements deposited in water bodies has also increased. These can accumulate to toxic levels in aquatic organisms and can be transferred to humans through fish consumption. Monitoring trace elements in fish is important for proper management of aquatic systems and the protection of human health. The aim of this study was to determine concentrations of trace elements in sediment and muscle tissues of *Clarias gariepinus* at Lake Ngami, in the Okavango Delta in northern Botswana, during low floods. The fish were bought from local fishermen and samples of muscle tissue were acid-digested and analyzed for iron, zinc, copper, manganese, molybdenum, nickel, chromium, cadmium, lead and arsenic using ICP-OES. Sediment samples were also collected and analyzed for the elements and for organic matter content. Results show that in all samples, iron was found in the greatest amount while cadmium was below detection. Concentrations of elements in sediment were generally higher than in fish except for molybdenum, which was below detection in sediment, and arsenic, which was 2.8 times more in fish muscles. To evaluate risk of fish consumption to human health, the target hazard quotient (THQ) and cancer risk for an average adult in Botswana, sub-Saharan Africa and riparian communities in the Okavango Delta was calculated for each element. All elements, except arsenic, were found to be below regulatory limits and to not pose a threat to human health. The results suggest that other benthic feeding fish species could potentially have high arsenic levels too. This has serious implications for human health, especially riparian households to whom fish is a key component of food and nutrition security.

Keywords: *Okavango Delta, African sharptooth catfish, target hazard quotient, cancer risk, health risk assessment.*

Climate change effect on forest-based livelihoods in Southern Africa: A systematic review

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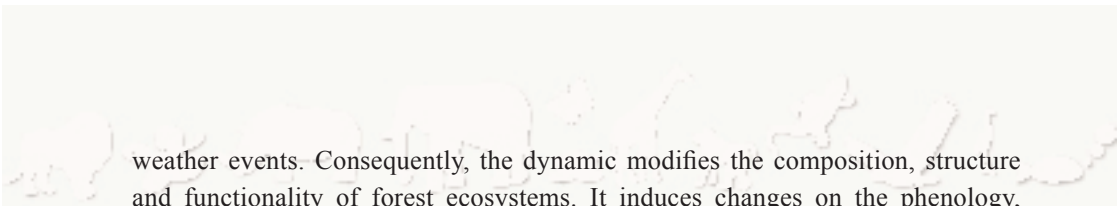
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Abstract

The contribution of forests to rural livelihoods is well known worldwide. But the unprecedented climate change and variability poses a greater threat to forest ecosystems and consequently rural economies. Little is known about the vulnerability of forest-based livelihoods to climate change dynamics, especially in developing regions. Since forests are integral to rural livelihoods, it is necessary to explore strategies for improving resilience and adaptation of rural communities to the threats posed by climate change and vulnerability. Against this backdrop, this review provides a synthesis on climate change and how it influences forest ecosystems and the resultant effects on forest-based livelihoods in Southern Africa. A systematic review of literature for the period 2000-2020 was conducted, with documents sourced from the following databases: Web of Science, Scopus, Google Scholar, and EBSCOhost. The search terms used for exploring the literature included “climate change, climate variability, forests, forest products, rural livelihoods and sub-Saharan Africa”. Thematic content analysis was used for analysing the data. Preliminary findings show that climate change and variability brings about formidable challenges to the livelihoods and wellbeing of forest dependent communities. Among others, climate change prolongs droughts, induces erratic rainfall, recurring fires, and increases the frequency of extreme



weather events. Consequently, the dynamic modifies the composition, structure and functionality of forest ecosystems. It induces changes on the phenology, species distribution and disturbance regimes of forests. As a result, climate change effects diminishes the productivity and vitality of the forest ecosystem, thereby impinging on the system's capability to supply key provisioning ecosystem services such as food, fuelwood, medicine, construction materials, and other non-timber forest products. Consequently, the livelihood source of the forest dependent community's is curtailed, a phenomenon which exacerbates them to other social shocks such as poverty and food insecurity.

Keywords: *Adaptation, Biodiversity, Climate change, Forests, Livelihoods, Vulnerability, Southern Africa*

Ensuring Permeable Landscapes In The Kalahari, Botswana: The Use Of Spoor Surveys To Study Wildlife Densities, Distribution And Connectivity

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Abstract

Since last century, the expansion of human and livestock activities in the Kalahari has become possible through the drilling of boreholes making water available throughout the year, bringing these activities to areas where before they had been only transitory. This has brought some conservation challenges in this region where the availability of resources is highly variable in space and time. These challenges include wildlife habitat degradation and competition for resources, as well as human-wildlife conflict. In this context, the study proposes to provide vital knowledge in ensuring the functionality of a key ecologically permeable landscape named the “Western Kalahari Conservation Corridor” (WKCC) linking the Central Kalahari Game Reserve to the Kgalagadi Transfrontier Park, through an improvement of human-wildlife coexistence. Part of the study involves running large-scale spoor surveys twice a year to collect data on 13 large wildlife species in the Ghanzi District Wildlife Management Areas GH3/10/11/13, with the assistance of experienced trackers from local San villages. I propose here to demonstrate how spoor surveys can be a very useful and affordable scientific tool to provide population density estimates of key wildlife species using the Formozov-Malyshev-Pereshin (FMP) formula, as well as wildlife distribution and connectivity information through spatial modeling to improve conservation and human-wildlife coexistence in the landscape, while involving local knowledge of citizens of the land.

Keywords: *Spoor survey; spatial modeling; density; connectivity; citizen sciences*

Effects of Elephants, Fire and Climate Variability on Woody Vegetation Bird Habitats in the Chobe National Park, Botswana

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Abstract

Chobe National Park (CNP) is one of the protected Important Bird and Biodiversity Areas (IBAs) in Northern Botswana that is however undergoing perennial losses of woodland. The loss is attributed to disturbances of fire, climate variability and intense activities of the African elephant herbivores. Woodlands of CNP are important habitat to a variety of bird species and as a result, their loss could negatively impact the population and diversity of these species. The current IBA habitat monitoring system in CNP employs collection of qualitative data which does not rigorously quantify spatio-temporal woodland cover losses. This study will investigate the application of geospatial techniques of remote sensing and Geographic Information System (GIS) in monitoring woodland bird habitat changes due to disturbances of elephants, fire and climate variability in the CNP IBA. MODIS and Landsat satellite imagery for years 2006, 2012 and 2018 will be acquired to map woodland loss and fire scars, respectively. As such, the Random Forest machine learning classification algorithm will be applied to separate and map woodlands from shrubland and other vegetation strata. After verification of the mapped results, time series change detection will be applied to note woodland cover changes between 2006-2012, 2012-2018 and 2006-2018. The established trends of woodland losses will be related to independent and synergistic occurrences of these disturbances through regression analysis. This study will demonstrate the potential for using geospatial techniques to monitor woodland habitats and advance the understanding of the effects of interacting disturbances on woody bird habitats as well as informing conservation entities on the current state of habitats within CNP.

Keywords: *Botswana, Chobe National Park, Geospatial techniques, Important Bird and Biodiversity Area, Woodland habitat*

Enhancing biodiversity conservation through environmental awareness in Ngamiland (Chukumuchu Village)

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Abstract

There has been substantial efforts locally on actions of Sustainable Development Goals (SDGs). Information on the level of environmental awareness is vital in informing intervention in biodiversity conservation. To find out the level of natural resources utilisation for improved livelihoods, environmental awareness was assessed in remote settlements in Botswana, a case study was undertaken in the village of Chukumuchu.

Chukumuchu (S18.7097°, E21.4398°) is a village in the North West District of Botswana (Okavango Sub-district). The settlement lies 50km North East of Gumare, and 120 km from Shakawe .The main livelihood activities are pastoral agriculture. Veld fire is a common occurrence in the area, with such incidents occurring almost every year. The village lies west of the World Heritage Sites of Okavango Delta and Tsodilo Hills, village lies on the boundaries of the Okavango Delta Ramsar Site.

Data collection comprised a structured questionnaire, administered through a house-to-house survey. Results suggested low level of environmental awareness, diverse flora availability including abundance of the protected *Baikiaea plurijuga*; Mukusi tree and wild berries with minimal utilisation thus low income. Capacity building, stakeholder engagements and follow-up monitoring are crucial to ensure sustainable utilisation in various neglected villages such as Chukumuchu.

Keywords: *Natural Resources Utilisation, Livelihoods, Environmental Awareness, Chukumuchu Village*

Dynamics of Human-wildlife conflicts in Botswana landscapes

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Abstract

Based on history, humans and wildlife species co-existed together for centuries. As a result, there has been vigorous interaction, bringing various implications depending on the context of the arguments. These interactions emanate from competition for space, forage and other resources. However, as human populations and settlements expanded, there has been a change in human-livelihoods, resulting in the reduction and modification of wildlife habitats, and declining wildlife populations in some areas. In the past decade, there has been a rise in human-wildlife conflicts (HWC) incidences across Botswana. However, the level and magnitude of these conflicts appear to vary at temporal and spatial scales as well as the wildlife species. While there are some useful studies on HWC across Botswana, few efforts were invested in documenting how these conflicts have been changing over the past 20 years. Data of HWC incidences per species, and compensation paid to local communities by the Department of Wildlife and National Parks (DWNP) for the past 20 years will be analyzed. This study broadens our knowledge and understanding on how variable the conflicts has been across species and regions over the years. It is envisaged that this information will contribute to policy formulation, especially in relation to development of intervention strategies aimed at reducing the HWC across the country. Ultimately, this will facilitate the management and conservation of wildlife species in Botswana.

Keywords: *Conflict, declining, human-wildlife conflict, wildlife ranges*

Photography: The cornerstone in biodiversity Conservation

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Abstract

Rationale The modern scientific advances the medicinal or cosmetic value of wild plants to improve human health and the global demands to produce food and feed the world's growing population is a threat to certain wildlife species and can lead to depletion of natural resources vital to the ecosystem. Identification of such through the involvement of communities and their leaders can lead to creation of a gene bank to protect and preserve them. Humanity is dependent on a well- balanced ecosystem for food, medicine, shelter and energy. This thus demonstrates that nature is an incentive for biodiversity conservation.

We aim to use the visual art of photography to create nature narrative that educates the communities whilst eliciting emotional attachment that lead to changes in the way humanity interacts with nature and its inhabitants.

Goal 1: To educate and create awareness towards environmental conservation through the use of photography.

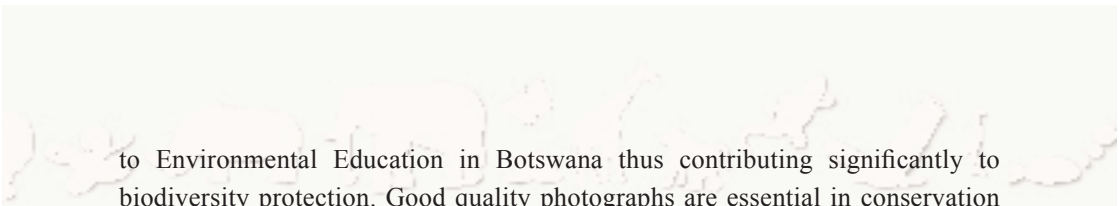
Goal 2: To form a supportive network that empowers and mentors youth in their conservation stories.

Goal 3: To collaborate with community leaders and researchers in the conservation and preservation of Botswana's natural capital.

Methodology

Qualitative method is the best method to be used for this application since it uses photographs and in some instances video recordings as well as audio recording would be used.

In Maun, we have Friends of Photography Conservation Society, an entity that uses photography as a medium to relay conservation messages to Out of School youth and Primary School students. The results thus far are promising and we are optimistic that going into the future this will turn the corner in relation



to Environmental Education in Botswana thus contributing significantly to biodiversity protection. Good quality photographs are essential in conservation campaigns so as to make sure the message gets across a large audience in a short period of time.

Keywords: *Photography, Conservation, Medium, Biodiversity*

