

# **A landscape approach to elephant conservation in Mozambique**

by

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# A landscape approach to elephant conservation in Mozambique

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## Abstract

People and elephants share landscapes throughout Mozambique. Here elephant conservation management focuses on protected areas but fails to address the conflict that exists between elephants and people. In this thesis I develop a landscape approach to conflict mitigation that is designed to accommodate the needs of people and of elephants in human-dominated landscapes.

Mozambique faces a dilemma: politically it is required to reduce poverty while at the same time adhere to international agreements and requirements to protect biodiversity with relatively scarce financial resources. Reactive mitigation of human-elephant conflict (HEC) at the site-specific scale have proven to be costly and with low efficacy. A shift from reactive to proactive HEC mitigation approaches at the county-wide scale (e.g. a district level, the administrative planning body) may provide opportunities to reconcile such apparent contrasting requirements in Mozambique.

The elephant population of Mozambique is fragmented and remnant sub-populations are limited to clusters of protected areas in a matrix of human-dominated landscapes. A metapopulation perspective may accommodate this spatial structuring and allow for a conservation plan that ensures population persistence and moderate impacts with other species in the landscape.

I assessed HEC throughout human-dominated landscapes of Mozambique to examine some assumptions associated with the landscape approach advocated here. I used spatially explicit human activity data, landscape features and elephant distribution at the grid cell of 25 km<sup>2</sup> and at the district scale to test the practicality of landscape approaches to elephant conservation and mitigating HEC in the human-dominated landscapes of Mozambique. I then

tested whether human activities have significant impacts on elephant numbers and distribution across Mozambique. Furthermore I tested if the costs and benefits of sharing space with elephants influenced HEC. Thereafter, I explored at the grain scale of 25 km<sup>2</sup> if the degree of overlap between them on the use of resources can be used to predict the likelihood of HEC across the landscape.

Direct and indirect human activities explained trends and rates of elephant population changes in Mozambique. Because most rural households of Mozambique rely on subsistence farming by extracting or cropping from the land, primarily for their own purposes, living close to elephant refuge areas represented a potential risk to humans. However, conflict with elephants does not centre on food security, but on lifestyle being affected by the presence of elephants, which itself was a function of human density. Rodents and insects are the primary agents responsible for food loss during food storage. HEC was not a function of elephant density – a combination of human density, percent cultivated area and human population growth rate best explained HEC incidences. Although at human densities beyond 60 people/km<sup>2</sup>, elephants disappeared, at low levels of land transformation and low human densities people and elephants co-existed, which may induce higher incidences of HEC. Proximity to roads and suitable land for agriculture were the best predictors for HEC in the rural areas of Mozambique. These results imply spatially driven causes of HEC.

These findings supported assumptions that conservation landscapes embedded in different land uses that accommodate ecological needs of people and elephants as well as the likelihood of severity of HEC can ensure elephant conservation without forcing people into poverty. While reactive HEC mitigation actions at site-specific scales are attractive for local

communities, proactive measures at the landscape scale may be more effective in the rural context of the distributional range of elephants in Mozambique.

HEC can be mitigated proactively through an effective land-use planning that involves zonation and implementation. To address this I extrapolated the relevant findings from resources selection functions models at the 25 km<sup>2</sup> grain scale for study locations to a country-wide scale and proposed a model of a likelihood of HEC. The country-wide HEC model yielded high predictive power and confirmed protected areas as sites of high elephant dependability. These models indicate focal areas for short to medium term reactive HEC mitigation measures and local community programs at specific site level.

This dissertation suggests that human and elephant co-existence is possible in Mozambique. The apparent increase of HEC is not a function of numbers of elephants but of improper land use planning. In this thesis I argue in favour of a landscape approach to mitigate conflict between elephants and people. This approach should be considered in all national plans that aim to reduce conflict and enhance conservation.



**For my parents,**

**Pedro and Bassaliza**

For your profound amazing love, support and wisdom, and the be late never reached and  
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## Disclaimer

This dissertation includes four manuscripts, one that has been accepted for publication and three prepared for different scientific peer-reviewed journals, which will be soon submitted. Styles and formatting of all Chapters follow requirements for the journal *Oryx*. This results in some duplication in study area description between Chapters 3 and 4 and methods description between Chapters 5 and 6. Chapter 1 is a general introduction and Chapter 7 summarizes general conclusions. I hereby declare all the work to be my own and that I have acknowledged all those who helped me and contributed in producing this dissertation.

Cornélio P. Ntumi

## List of abbreviations and acronyms

AEC	Anuário estatístico da colónia de Moçambique (Annual Statistic of Mozambique)
AGRECO	Agri Ecology Consulting
AIC	Akaike's information criteria
ANE	Administração Nacional de estradas (National Roads Authority)
ARA	Administração Regional de Água (Regional Water Authority)
ARD	Natural Resources Management & Development Portal
AWF	African Wildlife Foundation
BEE	Boletim económico e estatístico (Economic Statistics Bulletin)
CENACARTA	Centro Nacional de Cartografia (National cartography Centre)
CERU	Conservation Ecology Reserach Unit
CESVI	Italian Association for Cooperation and Development
CTV	Centro Terra Viva (Land Center)
DBC	Department of Biological Sciences
DEM	Digital Elevation Model
DINAC	Direcção Nacional de Áreas de Conservação (National Directorate of Conservation Areas)
DINAGECA	Direcção Nacional de Geografia e Cadastro (National Directorate of Geography and Cadastre)
DNEP	Direcção Nacional de Estradas e Pontes (National Directorate of Roads and Bridges)
DNFFB	Direcção Nacional de Florestas e Fauna Bravia (National Directorate of Forestry and Wildlife)
DNTF	Direcção Nacional de Terras e Florestas (National Directorate of Land and Forestry)
ESRI	Environmental Systems Research Institute
FRELIMO	Frente de Libertação de Moçambique (Liberation Front of Mozambique)
GLM	Generalized linear model
GLTFCA	Great Limpopo Transfrontier Conservation Area
GM	Governo de Moçambique (Government of Mozambique)
GPS	Global Positioning System
HEC	Human-elephant conflict
IFAD	International Fund for Agricultural Development
IIPPA	
INE	Instituto Nacional de Estatística (National Statistics Institute)
INGC	Instituto Nacional de Gestão de Calamidades (National Institute of Hazard Management)
INIA	Instituto Nacional de Investigação Agronómica (National

	Institute of Agronomic Research)
LTFCA	Lubombo Transfrontier Conservation Area
MA	Ministério da Agricultura (Ministry of Agriculture)
MICOA	Ministério para a Coordenação de Acção Ambiental (Ministry of Coordination of Environment Affairs)
MITUR	Ministério de Turismo (Ministry of Tourism)
MPF	Ministério de Plano e Finanças (Ministry of Plan and Finance)
NDVI	Normalized difference vegetation index
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration
PDF	Probability Density Function
RIHEC	Relative index of Human-Elephant Conflict
RP	República Portuguesa (Republic of Portugal)
RSF	Resource Selection Function
TEP	Tembe elephant Park
TIA	Trabalho de inquérito agrícola (Rural income survey)
UEM	Universidade Eduardo Mondlane (University of Eduardo Mondlane)
UIF	Unidade de Inventário Florestal (Forestry Inventory Unit)
UNFPA	United Nations Population Fund
WCS	Wildlife Conservation Society

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