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THE ECONOMICS OF ENDANGERED SPECIES REGULATION: A CASE STUDY OF *RHINOCEROS* PROTECTION AT NAIROBI NATIONAL PARK, KENYA

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ABSTRACT

The debate over regulation of endangered species is fraught with exaggeration and misunderstanding of the potential and actual economic benefit. The study aims to investigate if endangered wildlife species regulation was achieved at least loss of economic well-being (i.e. social benefits are more than social costs). The analyses first use the cost-benefit analysis model to calculate the net social benefit arising from protecting endangered species which can be due to households living adjacent to Nairobi National Park. It utilises the benefit transfer evaluation technique (unit value transfer) to achieve this. Secondly, because endangered species protection has impacts over extended period of time, the study make use of density-dependent model using rhinoceros population dynamics to inform on future timing to focus protection effort. The study determines the optimal population which can be accommodated without damaging the environment and ensure sustainability in regulating rhinoceros. The findings have far reaching consequences. Although the results indicate that protecting endangered species is a worthwhile endeavor and generate positive net social benefit if managed sustainably, it transpires that it is necessary to do more than just protecting the species. Harvesting plans need to be implemented to control further increases in rhinoceros population to avoid extinction probability and ensure that Nairobi National Park has a healthy productive population. In this study it is argued that protection efforts for rhinoceros at Nairobi National Park should be enforced until a sustainable population estimate of approximately ninety eight (98) species is reached, after which relaxing protection policy becomes necessary and morally justified in order to avoid greater suffering of endangered species and other creatures.

Keywords: Total economic value (TEV), Net Present Values, cost-benefit analysis, CBA, Non-timber forest product

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ACRONYMS AND ABBREVIATIONS

CBA	Cost-Benefit Analysis
CBNRM	Community Based Natural Resources Management
CITES	Convention on International Trade in Endangered Species
CV	Contingence Valuation
EAC	East Africa Community
GDP	Gross Domestic Product
IUCN	International Union for Conservation of Nature and Natural Reserves
KIHBS	Kenya Integrated Household Budget Survey
KNBS	Kenya National Bureau of Statistics
KWS	Kenya Wildlife Service
NPV	Net Present Value
NSB	Net Social Benefits
NTFP	Non-timber forest product
OECD	Organization for Economic Co-operation and Development

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PV	Present Value
SB	Social Benefits
SC	Social Costs
SDR	Social Discount Rate
SOC	Social Opportunity Cost
STP	Social Rate of Time Preference
TEV	Total Economic Value
TNUV	Total Non-Use Value
TRAFFIC	Trade Records Analysis on Flora and Fauna in Commerce
TUV	Total Use Value
T/S	This Study
USA	United States of America
WTA	Willingness to Accept
WTP	Willingness to Pay
WWF	World Wide Fund for Nature

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DEFINITION OF TERMS

Benefits Transfer – is a cost-benefit valuation method which calculates the values of ecosystem services at a site (referred to as the policy site) based on the results from hedonic analysis, contingent-valuation, travel cost, or other studies conducted at a different location (referred to as the study site or sites).

Biological diversity – is an umbrella term used to describe the number, variety and variability of living organisms in an assemblage. The variability among living organisms can be from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Species diversity refers to the variety and variability of species in a given region or area. **Ecosystem** refers to the ecological community, including plants, animals, and micro-organisms, considered together with their environment. It comprise the abiotic (non-living) environment and the biotic (living) groupings of plant and animal species called communities.

Benefits – are the sum of the WTPs for changes that are seen as gains and of the WTAs for changes that are seen as restoration of losses.

Cost-benefit analysis –A systematic process for calculating and comparing benefits and costs of a policy. Can also be referred to as benefit-cost analysis.

Economic value – is the total value added to national income, which reflects all income generated as a result of an activity, and not just the net profit for the investor or community. Economic value of biodiversity, then one always means the economic value of a change of biodiversity. It is not a question of determining the 'true' value of biodiversity or ecosystems but valuing changes and comparing them with their alternatives, e.g. with endangered species vice-versa without endangered species. A **value** is a figure (for a quantitative variable) or an attribute (for a qualitative variable) observed on a product. Values for products belonging to the sample will always be represented by small letters, capital letters being reserved for products of the population. **Valuation** can simply be defined "as an attempt to put monetary values to environmental goods and services or natural resources. **Total economic value (TEV)** – the direct and indirect use values plus option and non-use values such as existence value and bequest value. The TEV of a wildlife species is defined as the sum of use and non-use values. The concept of TEV is a widely used framework for looking at the utilitarian value of ecosystems or species. It assesses the TEV that a person, or a household, places upon non-marketable or only partially marketable commodities such as wildlife.

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Economics – is the study of the science of the administration or management of scarce resources. Its focus is mainly on the social mechanisms used for this purpose and their consequences for the satisfaction of human wants.

Endangered species – Any wildlife specified in the Forth Schedule of "The Wildlife Conservation and Management Act, 2013" or declared as such by any other written law or any wildlife specified in Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Keystone species – a species of strong interactions such that its presence in a system ensures that other species in place are protected and keeps the system from collapsing and a hemorrhaging of species losses.

Opportunity cost – the sacrificed benefits that could have been realised by another alternative with the same time, effort and resource expended or the economic value of the human efforts which are deployed to go in a given environment and are generally expressed in monetary terms (so many **€**, or so many **£** or so many **$**, etc.). It measures the value of what society must forgo to use the input to implement the policy. The concept of opportunity cost is used in CBA to place a dollar value on the inputs required to implement policies. The opportunity cost of using an input to implement a policy is its value in its best alternative use.

Present Value (PV) – refers to the value now of one or more payments to be received in the future.

Poaching – Illegally taking protected animals or plants.

Policy – refers to any of a wide range of decision choices, such as public or private projects (investments), programmes, policies and regulations. For the purpose of this study endangered species protection.

Simulation – is the process of using a model to mimic, or trace through step by step, the behaviour of the system under investigation. Simulating a natural resource management issue, such as rhinoceros conservation, under various external conditions and internal policy responses could provide important insights into how the system behaves to potential policy responses.

Social rate of Time Preference (STP) – the rate at which society is willing to trade present consumption for future consumption.

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CHAPTER 1

INTRODUCTION

1.1 Background

Kenya covers an estimated area of 584,000 km^2 (Milner-Gulland & Mace, 1998), with a population of about 43.0 million in the year 2014 (KNBS, 2015). Majority of this population live in rural areas, and consequently depend directly on biological resources as a basis for subsistence and economic activity. The Government of Kenya (KNBS, 2015) reports that Agriculture and forestry remains the main contributor to Kenya's Gross Domestic Product (GDP) of about US$18.6 billion, with an estimated share in real GDP of 30% in the year 2014. Tourism sector which is big business also continued to be an important source of Kenya's foreign exchange earnings in 2014. Tourism has an effect on people and environment and influence social and political decision making. A rapid rise in the population, has meant that land use become a contentious issue for Kenya and impacts directly on the poverty status. Although Kenya's poverty is on a declining trend and the risk of falling into poverty is lower today than in the 1990s, the prevalence of absolute poverty still remain high at 45.9% in 2005/6 from the 52.3% estimation experienced in 1997, with poverty being much deeper and severe in rural and remote regions (KNBS, 2007). This makes the achievement of the Millennium Development Goal of halving poverty by 2015 difficult. The situation also negatively impacts on Vision 2030, which aims at transforming Kenya into a middle-income country by 2030 by achieving sustainable annual economic growth of 10% and eradicate poverty by the year 2030.

Kenya has the richest biological diversity in Africa (Okech, 2010) which can be attributed to a number of factors including diverse habitat types and ecosystems. A significant percentage of these sites covered under protected areas network (Parks, Reserves & Sanctuaries) are home to an abundance and diversity of wildlife species across numerous habitats. Kenya's wildlife resource also constitutes a unique natural heritage that is of great importance both nationally and globally. Wildlife is the basis of the Kenya's tourism industry; an industry second only to agriculture as a national source of revenue, gaining recognition in Vision 2030 which supports the work towards a nation that has a clean, secure and sustainable environment through promoting conservation to better support the economic pillar's aspirations as it sets high targets on revenue and tourist arrival. On the whole, Kenyan people are depending on wildlife for livelihood, shelter, and for other ecosystem goods and services. Wildlife also fulfills critical ecological functions that are important for the interconnectedness web of life-supporting systems.

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However, the biodiversity of Kenya like in most developing countries is under threat (KWS, 2014). While most endangered wildlife species are threatened by habitat loss due to encroaching human development (Clinton, 2012), wildlife in Kenya is threatened by poaching, specifically for rhinoceros horns (KNBS, 2014). The poaching activity has intensified resulting in a devastating decline of species population during the 1980s (Spenceley & Barnes, 2005), making poaching a global challenge that spans continents, and needs to be addressed with partnerships that are robust and far reaching. This situation has seen global rhinoceros population falling from an estimated 75,000 in early 1970s, to about 30,000 by the year 2012, a figure less than the 100,000 rhinoceros which once roamed throughout Africa which has about 25,460 species remaining today (Wildaid, 2013). It is estimated that in Africa rhinoceros poaching especially in South Africa alone has increased from 13 species in 2007 to 668 species in 2012, rolling back years of conservation effort (Dudley, et al., 2013). This figure is more than the total of 523 rhinoceros poached in 2011 (Emslie, et al., 2012). Kenya Wildlife Services (KWS) reported that poachers had killed 8 rhinoceros by March 25, 2014, compared to 59 rhinoceros killed in 2013, while in 2012 only 30 rhinoceros were killed (KWS, 2014).

The Wildlife Conservation and Management Act is the most powerful law that deals with welfare issues affecting wildlife. The law provides the legal and institutional framework for the protection of endangered species and their habitats. The Act mandate KWS to be the lead agency in ensuring that Endangered Species and their critical habitats receive strong protection in conformity with the provisions of the Environment Management and Coordination Act of 1999. The Act provides for national agencies to designate critical habitats for endangered species and for the development of recovery plans designed to bring the species to a level of health such that it no longer requires protection under the Act. The Act also requires national agencies to ensure that their actions are not likely to either jeopardise the survival of listed species or adversely modify their critical habitats. Additionally, in line with Vision 2030 the Act necessitates that wildlife is sustainably managed for the benefit of the public as a whole and for present and future generation. This would make a significant contribution to promoting Kenya's economic growth through wildlife conservation and tourism by strengthening existing programs and developing new innovative approaches with regard to wildlife protection.

The Kenyan government has followed the global trend of making wildlife protection and production one of its responsibilities and implemented associated action plans and policies. Beyond trade bans and associated regulation, the government shifted its focus towards considering the wider socio-economic, ecological and cultural conditions under which intense conflicts arise. It ventured into other means like the adoption of the Community Based Natural Resources Management (CBNRM) which aims to achieve active community participation in wildlife conservation outside parks and nature reserves in line with the sustainable use approach

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which aims at maximising the benefits from wildlife. The view is that maximum protection of endangered species can be attained when, in addition to law enforcement at the national and international level, they are seen local as assets (Dublin & Wilson, 1998). The CBNRM involves four linked concepts: proprietorship, price, subsidiary and collaborative adaptive management. Collaborative adaptive management addresses the need for learning processes linked to stakeholders, complexity and change (Child, 2012). It recognises that given an opportunity communities will sustainably manage local resources if they are assured of their ownership and are allowed to use them for their own benefit or alternatively they should be given reasonable amount of control over the management of the resources (Gakunga, 2013). Realising that the above action plans and policies were not enough, efforts towards improving the infrastructure and acquire and use of high technology tracking systems, such as implanting microchips into the horns of every rhino, have been introduced in a bid to help conserve the species.

According to Bateman, et al. (2003), the issue of conservation and conversion is a conflict that is invirably resolved in favour of conversion. Kenya is not spared from this conflicting motive as government's wildlife protection action has continued to attract public attention, i.e. raising debates on the relative merits or demerits of protecting endangered wildlife species. Proponents of protecting endangered species contend that wildlife is a valuable resource. This was evident in debates on wildlife management where those in favour of wildlife protection may cite economic factors, while others who were against the protection of wildlife cite cases where species are a danger to mankind and are destructive to their crops and livestock and that protection efforts may restrict land from productive use by local communities. Additionally, the resources available for conserving the world's biodiversity are grossly inadequate for the task and also compete with other uses of national importance or economic activity. When resources for conserving biodiversity are severely limited there is need for strategic investments. Meijer & Berg (2010) highlight that for environmental policy to have effective outcomes; the societal stakeholders (e.g. citizens, government, companies) should clearly understand why it is so important to preserve the environment. Humans differ in how they value wildlife and its habitat. Wildlife management decisions must consider political, social, economic, and biological concerns with decisions involving all interested or potentially affected constituencies.

When contentious debates about critical habitat designation and sometimes conservation management raise economic issues, decision makers find themselves in the search for information that will contribute directly to the policy debate. Accordingly, wildlife protectionists are under increasing pressure to provide economic justification for their existence, i.e. accountable governments need to give reasons for engaging in protection of wildlife because choices and trade-offs have to be made in the context of scarce resources (i.e. money, time, and natural resources) considering that societies aren't provided with any "free lunches." Wall, et al.

(2003) highlights that in today's world economic solutions are sought for decision making with regard to wildlife protection because a series of decisions that individually do not have major effects can have major cumulative effects. The study is motivated by the need to understand the impact of endangered species regulation. For all the public and media attention attracted by endangered species protection there has been surprisingly little critical analysis on protection efforts published in an accessible form. The study makes use of economic tools, the application of a cost-benefit analysis (CBA) methodology, the cornerstone of the economic analysis of policy (Bellinger, 2007) to real-world decision making to devising means to halt and reverse the trend toward species extinction and focused on endangered species protection of rhinoceros.

Economic analysis play a formal and key role in the designation of critical habitats. A cost-benefit analysis seeks to embrace the range of costs and benefits values that legitimately can be used to determine the consequences of regulatory actions by allowing for an assessment of whether the benefits are likely to outweigh the costs. It is necessary to know the trade-offs involved in policy choice to balance the cost of an action against its benefits, and evaluate whether economic factors really are critical in each specific case. Brockington et al. (2006) states that understanding of how protected areas or community conservation works depends on understanding amongst other things, the distribution of costs and benefits. The analysis presented here is a first step towards stimulating more informed dialogue and provoking questions for which answers maybe found. So, if the output of a cost-benefit study is furnished for consideration by decision makers, it is likely to improve policy outcomes or avoid bad policies. Economic evaluations form part of a cost-benefit analysis and generally focus on the counterfactual, i.e. what would have happened had the action not been taken. Any environment study that aim to improve the quality of life or to generate an economic benefit should at the same time reflect the damage the environment will likely suffer because of the economic undertaking (Munier, 2004). Economists have since extended the analyses to follow the concept of sustainability, thus the need for an asset check, i.e. the trend which the stock of assets are likely to follow as a result of the protection effort.

1.2 Statement of the Problem

Protection efforts for endangered species sometimes lack public support and there exists conflicting motives on whether or not to protect endangered wildlife species. Studies (Naidoo & Ricketts, 2006; Shwiff, 2004; Shwiff & Sterner, 2002; & Shogren & Tischirhart, 2001) have shown that there have been few efforts to compare ecosystem service benefits with costs of service delivery. Although the evaluation and appraisal of projects through cost-benefit analysis is necessary it is often overlooked in Kenya (Njihia & Odock, 2008). Evidence from contingent valuation, hedonic pricing and other economic valuation tools underscore the importance of

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biodiversity and ecosystems, these give incomplete, lower-bound estimates of their values (Gowdy, et al., 2010). The lack of standard test of protection policy worthwhileness due to absence of net present value (NPV) calculations make it difficult to determine whether wildlife protection is economically justified. Even though the Kenyan government has followed the global trend of making wildlife protection and production one of its responsibilities and implemented associated action plans and policies, the illegal killing of endangered species for the international trade continues and has become a serious threat to wildlife and the underlying economy. It is estimated that globally between 1970 and 1992, approximately 96% of the black rhinoceros population was lost. Poaching levels in Kenya remain relatively high, with fifty nine rhinoceros poached during the year 2012/13 representing a 96.7% increase from the previous year (KWS, 2013).

There is very little published work in Kenya on studies which compare wildlife benefits to the opportunity costs of conservation, raising questions on the worthwhileness to spend huge sums of money on preservation of endangered wildlife while there is severe shortage of conservation funding and competing budgetary constraints. Little attention has been focused on gathering specific information of value that can be assigned directly or indirectly to protection of endangered species. As a result, we do not have rigorously grounded criteria for choosing among biodiversity-preserving alternatives, making performance evaluation difficult. In order to ensure that species protection provide the maximum biodiversity benefits and make the most of limited conservation budgets, a transparent and rigorous decision making framework is required.

1.3 Objectives

1.3.1 General Objective

The study aims at contributing to the body of knowledge on the value of protecting endangered species using the rhino case study in Kenya.

1.3.2 Specific Objectives

The specific objectives were:

I. To estimate the social benefits and social costs born from protection of endangered species;
II. To estimate the Net Present Values (NPV) of social benefits and costs, comparing them and ascertain whether rhinoceros species protection is delivering greater net benefits or losses; and

III. To estimate the future period of which protection efforts should be focused through the use of the framework of species population abundance.

1.4 Research Questions

The study aimed to answer the following fundamental questions:

I. What are the social benefits and social costs for protecting endangered species of rhinoceros?
II. Do the social benefits born from endangered species regulation outweigh the social costs?
III. What is the future period of rhinoceros protection that provides the optimal quantity of endangered species?

1.5 Justification of the Study

Implementation of policies often demand allocation of scarce resources, and therefore the need to be accountable for such resources. In light of this demand for accountability, there exist a need to pass an economic judgment on the estimated worth of the action. This is where cost-benefit analysis has a role to play, one must translate the costs and benefits associated with the policy, explicitly into monetary terms.

Endangered species are keystone species. They generally serve as indicators of larger environmental problems. So, preserving such wildlife species automatically ensures preservation of any anthropocentric values they might possess.

1.6 Significance of the Study

The study uses cost-benefit analysis as a decision analysis tool, designed to provide information aimed at formalising government decision making. If the regulation of endangered species is worthwhile, the benefits must be greater than the costs. The analysis is necessary to facilitate decision making, through provision of useful information about the future of protecting wildlife. It will be of use to a wide spectrum of readers including: academics, policy makers, and conservationists at all levels, from local trusts to international NGOs.

1.7 Scope of study

The study is focused within the practical realm of decision making in regulation of endangered species. The results will be used as an advocacy tool to help change local attitudes towards reversing the decline in population of the endangered species. Using the rhinoceros as a case study, this study seeks to contribute to the existing debate on whether or not to protect endangered species, especially given that there are other important competing goals for available budgetary resources.

The researcher considered both costs and benefits of managing endangered species in Kenya from the social perspective and from the point of view of current generation and then extended the analysis to include future generation because an investment involves sacrificing current consumption for future satisfaction. The analysis adopts year 2015 as the base year, and extends to a period determined by the optimal carrying capacity of the area available for conserving rhinoceros. The available land area is a constraint, and is informed by species population growth rates and acceptable carrying capacity. For the information to be most useful for decision making, it is helpful to compare the present values of the benefits produced by the policy (the "with approach") to the present values of the opportunity cost (the "without approach") produced by the policy. That is, the study uses the "with-and-without approach. Additionally, the analysis set aside benefits and costs with transfers off-setting each other because it either gives a zero value or might be very complex to trace them.

1.8 Limitations of the Study

Ideally, conservation protection studies are estimated on the basis of primary research at the study area for which information is desired. However, the researcher was limited to the use of benefit transfer of valuing benefits and costs instead of the preferred site-specific study because the time available to complete this study was limited and funds were lacking combined with data availability, which is a common problem in environmental resource management studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the relevant literature on economics of regulating endangered wildlife species. This includes the theoretical frameworks review, empirical review of past studies, and research gap.

2.2 Theoretical framework

This study examines if it is worthwhile to regulate endangered species of rhinoceros in Kenya and extends the analysis to determine the future period through which rhinoceros protection efforts must be extended to ensure sustainability, i.e. meet the needs of the present population

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without compromising the ability of future generation to meet their own needs. Literature on natural resource economics implies that the best way to conserve wildlife and their habitat is to encourage effecient and sustainable use of these resources. Munier (2004) observes that, any environmental study that aim to provide information on how the quality of life can be improved or how to generate an economic benefit should, at the same time reflect the damages that the environment will suffer because of the economic undertaking. Accordingly, three theories were of paramount importance in guiding this study.

2.2.1 Kaldor-Hicks Compensation Theory

The foundation of cost-benefit analysis (CBA), which is a subject of the study, is a welfare-change measurement (Wall, et al., 2003) and has a firm basis in the theory of "Pigou's Economics of Welfare" of the later 19th century and extended to the "new welfare economics" of the 1930s which reconstructed welfare economics on the basis of ordinal utility only (Pearce, et al., 2006). The extension of the work resulted in the beginning of the fusion of the new welfare economics, i.e. the Kaldor-Hicks compensation criterion, a test used as the means of deciding whether a policy enhances social welfare or make people better off, representing an improvement in economic efficiency of just the resources affected by the proposed policy (e.g. wildlife protection). The Kaldor-Hicks potential compensation principle postulates that possible beneficiaries of a policy under scrutiny can potentially compensate any possible loser, making all parties better-off. From a welfare economics perspective, sound public intervention may be justified under the notion of a potential Pareto improvement: that is, if the overall benefits of the public intervention exceed its costs (Hoyos & Maries, 2010). The suggestion is that at the very minimum, it is reasonable that society should not pursue policies that do not advance improved well-being. Rather, key is to identify the policy, programme or project for which the difference between benefits and costs is positive.

2.2.2 Economic Value Theory

The economic value has its theoretical grounding on Adam Smith, the father of modern economics. According to Adam Smith, the word value has two different meanings: the utility of some particular object, i.e. use-value and the power of purchasing other goods that possession of the object can convey, i.e. exchange-value (Zhang & Li, 2005). The one may be called "value in use"; the other, "value in exchange". Meanwhile valuation has its base from the Neo-classical economics perspective that acknowledges the intrinsic value of biological conservation, and the ideology that species, biodiversity, and environmental resources will be preserved if they are valued by society more than other goods (Sterner, 2009). Economic valuation is an attempt to provide an empirical account of the value of services and amenities or of the benefits and costs of proposed policy actions that would modify the flow of services and amenities (Wall, et al.,

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2003). Kotchen & Reiling (1998) highlights that as species protection efforts conflict with economic activity, measuring public values for endangered and threatened species becomes more important; i.e. understanding both the economic benefits and costs of conserving ecosystems can help to allocate scarce budgetary resources most efficiently (Naidoo & Ricketts, 2006) and determine whether motivation for or being against wildlife protection is related to market benefits or costs that would already be counted in the benefit or cost side of a cost-benefit analysis respectively (Loomis, 2000), off-which real and positive benefits resulting from species recovery helps avoid any false implication about wildlife protection efforts.

Ferber et al. (2002) states that value systems or 'economic or monetary valuation' of biodiversity guide human judgment and action: i.e. "frame how people assign rights to things and activities, and also imply practical objectives" (Erickson, 2000); "it provides a way of arriving at a decision that maximises well-being; it provides a way of trading off objectives; and it is effective since it speaks in the economic language to which policy makers listen" (Ninan, et al., 2007). Child (2012) acknowledges the existence of 'the price-proprietorship hypothesis' which suggests that if wildlife is valuable, and if this value accrues to landholders, then there is a high probability that landholders will manage wildlife sustainably, just as they would manage livestock. The economic perspective is that ecosystems and the services they provide are important in terms of its use or potential use value to society i.e. a 'utilitarian' view. Utilitarianism, which judges the effectiveness of actions by how well they contribute to satisfying people's preferences, is the basis for most mainstream economic analyses of value (Wall, et al., 2003). The suggestion is that people also value ecosystem services and species and value is important for calculating welfare effects of potential policy changes, i.e. for use in cost-benefit and other type of analysis. Biller (2007) highlights that to be more relavant for policy making, economic valuation of biodiversity should measure marginal or discrete local changes in the availability of biodiversity.

2.2.3 Density-Dependent Population Growth Theory

The theory on population growth can be traced from Charles Darwin (1859), advanced by Thomas Malthus (1978), in his essay on the principle of population (Mills, 2007). Darwin's assumption is that population would not increase geometrical or exponential for long periods. Eventually, there will be feedback between the density of the population and its growth rate. Thomas makes two postulate. First, food is necessary to the existence of man. Secondly, population, when unchecked, increases in a geometrical or exponential ratio, meaning that a constant fraction of the current number is added to the population each time step. The theory suggest that no population can grow without limit for long, population growth is a multiplicative process, greater variation in future population sizes leads to an increase in extinction probability. Hardisty (2010) acknowledges that the economy and the environment are inextricably linked; the economy cannot exist without a healthy robust environment. The theory postulates that continous

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growth of population is unrealistic. Increased species population will lead to high level of density which is assumed to increase the exploitation of limited resources and force the population to stabilise near an equilibrium density, often called the carrying capacity. Ecosystems should be modelled in accordance to the Solow-Hartwick approach for economic sustainability, i.e. maintaining the capital stock necessary to insure that economic output does not decline (Gowdy, et al., 2010).

2.2.4 Economic Consideration and Implication for policy

The review of existing literature on economics of wildlife protection has been extensively debated and investigated in the past. Some studies reveal that policy and management decisions designed for protecting wildlife involve competing resource uses and conflicting value systems, rarely free of criticism from adverse economic impact, kindling controversies or conflicting motives pitting species protection against economic concerns. With these perceptions in mind, conservation program are found lacking "voluntarism" in participation as they suffers from lack of standard test of its worthwhile. Revesz & Stavins (2004) acknowledges that the economic concept of the value or benefit of environmental goods and the services they provide is couched in terms of society's willingness to make trade-offs between competing uses of limited resources, and in terms of aggregating over individuals' willingness to make these trade-offs. Accordingly, there is need for hard evidence that the benefits of preservation exceed the alternative uses of the available resource that is being protected. Economics as the study of the science of the administration or management of scarce resources focuses mainly on the social mechanisms used for this purpose and their consequences for the satisfaction of human wants. According to Frisvold & Innes (2009) the discipline of economics can play a formal role in the designation of critical habitat. It can help inform policy makers about the social benefits and costs of species protection. For instance, environmental economics can inform conservationists and policy makers about why species are endangered, the opportunity costs of protection activities, and the economic incentives for conservation (Martín-López, et al., 2008) and help equip decision makers to be able to identify weak rationale and challenge bad decisions and provide some direction for future policy measures (t' Sas - Rolfes, 1997). Where these kinds of solutions don't readily exist, and local communities have no way of benefiting from wildlife or from the ecosystems in which they live, there is an extremely low tolerance of wildlife and wildlife related losses, considering that just like firms and other productive resources, wildlife species have economic value. To know "how much the policy will cost and what kinds of benefits it produces" is of paramount importance and can be used to inform current decisions during advocacy work or to be aware of the pitfalls of a preservation policy which may lead to amendments of existing policies and/or creation of new ones. As for this case, the economic issue is one of measuring what is being lost when wildlife is lost because if decisions are made and they turn out to be extremely costly, little can be done to reverse them (Pearce, et al., 2006). Unless and until the social and economic implications are clearer, governments are likely to continue to give insufficient weight to policy decisions. Improving the economic case for wildlife protection is, therefore, an important goal as conservationists find themselves overwhelmed on debates about wise wildlife management strategies for some time.

2.2.4.1 Cost-Benefit Analysis

According to Ngunjiri (1999), the evaluation and appraisal of projects is necessary to relate costs and benefits (Njihia & Odock, 2008). Social Cost Benefit Analysis (CBA) is a popular decision standard that is used to decide whether a policy or programme should be implemented. It is the most thorough form of policy analysis, which attempts to estimate dollar values for all benefits and costs, even when the good in question is never actually bought or sold and has no explicit market value (Bellinger, 2007). Central to CBA as it applies to environmental issues is the idea of an externality, a third party detrimental (or beneficial) effect for which no price is exacted, i.e. in an unregulated market, individual users of a common natural resource would have no incentive to account for the suffering and damage borne by third parties (Pearce, et al., 2006). Policy analysis of wildlife resources is done to internalise externalities into public decision making. CBA is one of the most commonly used methods of decision making but continues to receive heavy criticism from difficulties encountered in practice. It is an economic tool with procedural steps based in the logic, values and assumptions of welfare economics which emerged out of the need by political decision makers for a method for systematically assessing alternative public projects to enable consistency in analysis (Weimer & Vining, 2011; Weimer, 2008; Loomis & Helfand, 2003; Munger, 2000 & Fuguitt & Wilcox, 1999).

The allocation of resources (e.g. into wildlife protection) may result in pareto improvement if the benefits of wildlife protection exceed its costs. Benefits are defined as increases in human well-being (utility) and costs are defined as reductions in human well-being. Benefits exceed costs when the benefits to individuals who gain from the public good exceed the benefits of goods forgone by individuals elsewhere in the economy. Economists refer to benefits forgone elsewhere as ‘opportunity costs’. CBA makes use of the Net Present Value (NPV), attained by use of reliable estimates of social benefits and costs, including estimates of the social discount rate, measuring whether the resource management action represents a Potential Pareto Improvement over the life of the policy. The social benefits and costs of wildlife protection are estimated in monetary terms and then compared over time and across people, a landscape or region for individual land parcels or units. In a CBA, if the benefits accruing to society (including the proponent of protecting rare wildlife species from becoming extinct exceed the costs associated with the policy, then the policy is worth undertaking. If costs vastly exceed benefits, it surfaces that society is losing, and then the funds could have been spent in a way that

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would benefit society more. From Ackerman & Heinzerling (2002), the belief is that this rationalisation of a course of action of any governmental agency would produce a sound regulatory process, is one that is more objective and more transparent, and thus more accountable to the public (Hardisty, 2010; Sterner, 2009; Elliott, et al., 2008; Pearce, et al., 2006; Campbell & Brown, 2003; Engeman, et al., 2003; Loomis & Helfand, 2003; Layard & Glaister, 1994).

2.2.4.2 Valuation Techniques and Benefit Transfer or Value Transfer

Economic valuation can provide important inputs into policy making. It can be used to estimate the relative importance of a conservation policy and provide a justification or an evaluation of the conservation decision through identification of the distribution of the benefits and costs of that policy. The most common welfare changes valuation is done using market prices under certain conditions, or changes in consumers' and producers' surplus when prices change. However, in many cases the marginal social cost or marginal social benefit will not be equal to market prices (especially where markets for environmental goods and services is lacking), in which case shadow prices need to be calculated. Sterner (2009) acknowleges that to-date statutory fines (SF) provided by legislation provides for statutory fines that can be used to value species and is perhaps the most direct technique in that it has statutory provisions for illegally harming or disturbing listed species. Alternative methods, i.e. Captive Breeding Costs (CBC), Contingent Valuation analysis (CV), Hedonic Pricing (HP), Travel Costs (TC) methods have also been devised to gain estimates of the monetary value (i.e., "monetise") that people place on treatened species in economic research and models. Because resources are scarce, consideration must be made to that every choice involves a cost and the best measure (highest-valued alternative) of economic loss is opportunity cost of resources, the value of the foregone opportunities due to restrictions on the use of property due to listings, designation of critical habitat, and recovery plans and include implicit as well as explicit costs (Shogren & Tischirhart, 2001; Krugman & Wells, 2009). Accordingly, one has to decide whether to do something or do nothing or something else and to make this decision, there is need to calculate the net economic benefit (Net Present Value) – the revenue receipts minus the true cost of anything which is its opportunity cost, including the reduced economic profit from restricted economic activity. Basically, there are three main categories of value relative to which costs and benefits are estimated: direct use value (i.e. individuals make actual use of a resource for either commercial purposes or recreation), indirect use value (i.e. where society benefits from ecosystem service) and non-use (existence) value (i.e. where individuals are willing to pay for the option of using a resource in the future). Ferraro, et al., 2011 organised his literature review into six types of ecosystem services: carbon storage, ecotourism, hidrological flows, pollination, health, and non-timber forest products (NTFPs). Economic values include the direct economic contributions of biodiversity including eco-tourism, recreation, and the value of direct biological inputs such as

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crops, fisheries and forests and these values can be very large (Gowdy, et al., 2010). Kroeger & Manalo (2006) classifies the categories as shown in Table 2.1 that follow.

Ideally, conservation protection studies are estimated on the basis of primary research at the study area for which information is desired. However, due to limited time and resources when decisions have to be made, new environmental valuation studies often cannot be performed, and decision makers try to transfer economic estimates from previous studies (often termed study sites) of similar changes in environmental quality to value the environmental change at the policy site. This procedure is most often termed benefit transfer, but could also be transfer of damage estimates. Thus, a more general term would be value transfer. The general process is to transfer existing estimates of values to a new study which is different from the study for which the values were originally estimated. Once the monetary values of the protected species have been established, economic analyses can be used to evaluate whether wildlife management is a fiscally responsible approach for species conservation, or it can be used to provide efficacy comparisons among multiple approaches. Furthermore, recognising that added uncertainty is inherent in value transfers, one should try to avoid value transfer when the need for accuracy is large.

Table 2 1: Categories of Values and Associated Benefits Provided by Ecosystems and Species

Value category	Benefit
Use values	
• **Direct use values (i.e. individual make actual use of a resource for either commercial purposes or recreation)**	Non-consumptive recreation (e.g., wildlife viewing) Consumptive recreation (e.g., hunting) Consumptive non-recreation (e.g. watershed, medical & medicinal substances) Education & research
• **Indirect use values (i.e. where society benefits from ecosystem service)**	Pollination services Carbon sequestration Erosion prevention Water Regulation/watershed conservation Habitat Provision, etc.
	Possibility to engage in direct use of the resource in the future (e.g. future visits to a

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• **Option value (i.e. where individuals are willing to pay for the option of using a resource in the future).**	wilderness area)
Passive use values (Non-use values	
• **Existence Value**	Appreciation of the scenic beauty of the protected wildlife areas and the natural systems it contains
• **Stewardship value**	Appreciation of the fact that this scenic beauty and the natural systems are maintained for and are...
• **Bequest Value**	Satisfaction from passing wilderness preservation benefits on to future generations

Source: Adapted from (Kroeger & Manalo , 2006)

Consideration should be given to the following: the validity of a value transfer will be higher if the good that was valued in the source study is similar to the good that will be changed at policy site, in terms of the definition of the good itself, the degree to which it will change, and the population affected and the transfer of values based on value functions is more robust than the transfer of unadjusted average unit values since effectively more information can be transferred (Navrud & Ready, 2007; Ninan, et al., 2007; Wilson & Hoehn, 2006; Bateman, et al., 2003; Navrud & Bergland, 2001; Brouwer, 2000).

2.2.4.3 Time Discounting

2.2.4.3.1 Discounting

According to Campbell & Brown (2003), when calculating present values for use in a social cost-benefit analysis we need to make a decision about the appropriate rate of discount, rather, the range of discount rates to be considered which is a key choice. The discount rate is a crucial variable in CBA (Njihia & Odock, 2008). The theory of discounting can be traced from Ramsey (1928) and Solow (1999). Burgess & Zerbe (2011) acknowledges that the case for discounting arises from the concepts of time preference, uncertainty, and the opportunity cost of capital, all of which amalgamate to underlie the simple premise that the preference of benefits or money is earlier rather than later. The choice of a discount rate directly influences the relative value placed on benefits and costs flowing to different generations and reflects judgments about the nature of risks and citizens' responsibilities toward future generations because environmental policy seeks

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to avert harms to people and to natural resources in the future, not only within current generation, but within future generations as well. The discount rate tells us the rate at which we are willing to give up consumption in the present in exchange for additional consumption in the future. If a policy is extended into future periods, the monetary impacts of each period must be discounted back to the current period and evaluated in the current period. (Hardisty, 2010 & Campbell & Brown, 2003).

Davis & Mikesel (2014) highlights that for social economic analysis; discount rates are typically significantly lower than typical commercial rates and vary from about 2.5% to 6% per annum. Lower rates are used in social analysis because higher discount rates effectively devalue the future; declining discount rates are preferred based on the premise that use of higher discount rates results in such high discount factors that future benefits and costs do not matter today (Loomis & Helfand, 2003), a benefit that arises in a hundred years is almost worthless in present value (PV) terms. However, Hanley & Barbier (2009) states that cost and benefit flows are discounted using a discount rate which is assumed to be the rate of interest. The use of the interest rate is based on fact that it correctly measures the cost of delaying the receipt of a dollar of benefit and, correspondingly, the benefit of delaying the payment of a dollar of cost (Krugman & Wells, 2009). The use of inflation is rejected because inflation can result in future benefits and costs appearing to be higher than is really the case and should be netted out to secure constant price estimates (Pearce, et al., 2006).

2.2.4.3.2 Future Time Horizon

According to Heal, et al. (2005), if the benefits and costs of a policy are evaluated, the benefits and costs associated with changes in ecosystem services should be included along with other impacts to ensure that ecosystem effects are adequately considered in policy evaluation. Any economic analysis of ecosystem services has to appraise the impact of potential stock depletion in order to assess the sustainability of given states (Bateman, et al., 2010). Consideration of the future time horizon emanates from understanding that investment decision has a time dimension because it involves sacrificing current consumption for future satisfaction (Brent, 2006). Studies have shown that benefits and costs of wildlife protection occur at differing time horizon and policy specific conditions should dictate the appropriate time horizon upon which to conduct an economic analysis, that is, tailor the time frame to capture all benefits and costs likely to arise from the policy. Couple this with the idea that animal over-population threaten habitats and other species because there are significant diminishing marginal returns to increases in wildlife population which as their densities increases can cause a serious disruption (negative feedback) of ecological balance. Conservationists find themselves concerned with individual indicator species only in cases where they promote the preservation of other species. Relaxing protection policy in the future is necessary and morally justified in order to avoid greater suffering of endangered species and other creatures. Adcock (2001) supports around 75% of carrying capacity as one important way of promoting rhinoceros productivity, preventing density dependent declines in rhinoceros breeding performance and increases in mortalities. Negative density-dependance thus regulates population numbers within some equilibrium size range (carrying capacity) by decreasing population growth at higher density and increasing it at lower density. This step makes use of species population growth (any trajectory in abundance over time) due to density (abundance per unit area) which is vital for determining species harvest regulations for deciding on protection of species (Mills, 2007). The simplest way of calculating population growth being the geometric or exponential growth where a constant fraction of a current number is added to the population each time step. Meanwhile a common way to model negative density-dependence is as a logistic growth function, whereby per-capita growth rate realised declines linearly with increasing density and becomes zero at carrying capacity (Mills, 2007; Milner-Gulland & Rowcliffe, 2007).

2.3 Empirical Review

Demir (2013) studied the importance and limitations of studies aimed at the ecomonic value of biodiversity to be determined as monetary. The study targeted an interpretation of the economic valuation concept by approching key studies aimed at building bridges between a nation's ecology and its economy. The study highlights a need to revealing the value of the biological diversity both quantitatively and qualitatively. This and previous studies ignore the important concept of finding the defference between valued benefits and the opportunity costs, while concluding that the available economic valuation estimates should be considered, at best, at a lower bound to an unknown value of biodiversity. The study supports the use of CBA which always try to find both values and can help contribute to debates of environmental economics and public policies.

According to Hardisty (2010), economists justify an expenditure based on the anticipated benefits resulting from that expenditure and prescribes that wildlife should be preserved as long as the marginal social benefits of doing so exceed the marginal social costs (Walpole, et al., 2001). If the benefits accruing to society from a policy exceed the costs of implementation, then the policy is worth undertaking. This is what is termed as the economic efficiency, the net benefit or net present value (NPV) criterion which asks whether the discounted value of future benefits is greater or less than the discounted value of future costs, added up over a defined time period (Hanley & Barbier, 2009) and is promoted as the sole decision making criterion. The absence of NPV calculations can lead to spurious results and to the acceptance of a project that is economically inefficient.

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Burgess & Zerbe (2011) developed a discount rate that could serve as a standard for best practice for selecting the best projects in terms of maximising net present value and meet the potential Pareto test. They reconciled different suggested procedures for determining the discount rate and found that the social opportunity cost of capital (SOC) approach to the discount rate is superior in its generality and its ease of use. The SOC approach suggests discounts rates of 6% - 8% and proposes that the discount rate reflects the social (economic) opportunity cost of capital, a weighted average of the pre-tax and after tax rates of return, and in an open economy, the marginal cost of foreign funding, where the weights reflect the proportions of funding that are obtained from displaced investment, posponed consumption, and increamental funding from abroad when the government borrows to finance the project. In Kenya this rate has fluctuated between 6% and 9% (Olweny, 2011).

Okita-Ouma, et al. (2009) studied density-dependence and population dynamics of the Kenya black rhinoceros. They used population models to examine the interrelationship between density-dependent factors, sex ratio and underlying growth rates (***r***) for black rhinoceroses living in three rhinoceros sanctuaries in Kenya, Nairobi National Park inclusive. The study examined how changes in population density and adult sex ratios correlated with underlying intrinsic growth rates over time. The results indicate that the exponential model was accepted because it was found to better portray the actual situation on the ground and the population growth rate was found to be 3.0% and the average density to be 0.54 rhinos/Km^2 (63 rhinos) and was above the estimated maximum stocking density of 0.34 rhinos/Km^2 (40 rhinos). The conclusion reached was that Kenya's rhinoceros sanctuaries have great potential to provide a substantial and continous surplus of rhinos for re-stocking other areas.

Ninan, et al. (2007) examined the uses and economic values derived by the tribal communities from the Nagarhole National Park. They also analysed the perceptions, attitudes and the value preferences of the tribal communities towards biodiversity conservation in general, and wildlife protection in particular, taking the case of elephants, a keystone and threatened species, in the study area for an in-depth study. The study was based on their willingness to accept the compensation (i.e. rehabilitation package) offered by the government and relocate outside the national park, and the socio-economic factors influencing their responses. The reasons why the communities were not accepting the rehabilitation package were also examined. Their analysis revealed that the opportunity costs of biodiversity conservation in terms of the forgone coffee, agricultural, Non-timber forest product (NTFP) and other forest resource benefits were quite high. Hence, the local communities within or near forests and protected areas needed to be compensated by the global community at large and others who benefit from biodiversity conservation in order to give an incentive to them to forgo the development option.

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De Boera, et al. (2007) uses a cost-benefit analysis, in order to assist in the optimisation of the management activities of the elephant population, based on elephant population size, fence costs, crop raid costs, elephant poaching, and benefits derived from tourism (game-viewing and hunting). The concession holder sought to maximise the present utility value over a long-term time horizon (the concession period, assumed infinite). Thus a discount rate of 5% for future earnings was incorporated in the model. The study used a combination of primary data and secondary data (i.e. estimates of benefit and cost values transferred from previous studies). The results indicated that the fence construction is an economically viable activity at elephant population size for the period under consideration.

Naidoo & Ricketts (2006) conducted a spatial evaluation of the costs and benefits of conservation for a landscape in the Atlantic forests of Paraguay aimed at estimating the benefits of ecosystem services to society as a whole. The study was based on a utilitarian view of conservation, where benefits and costs are assessed in purely economic terms. Five ecosystem services values were estimated as the opportunity costs of conservation or the cost of conserving the natural habitat that underlies their provision. Benefit-transfer approach, using a combination of marginal and average values was the method adopted for calculating of ecosystem service benefits. The cost of endangered species management were best described in terms of the value of alternative opportunities forgone or simply opportunity costs which exist with public policies, because resources devoted to species conservation could have been spent on something else viewed as potentially more valuable to the general public. Highlights of the study findings were as follows: both benefits and costs of conservation varied enormously across the Mbaracayu Biosphere Reserve; this spatial information can inform conservation and land use decisions but was currently lacking in most conservation planning exercises; economic benefits of conservation are substantial and, depending on which services are counted, outweigh costs in certain areas and financial mechanisms in these areas that capture the economic value of ecosystem benefits can help finance conservation, freeing up resources for investment elsewhere; and accounting for the costs and benefits of conservation can help illuminate economic trade-offs for specific decisions. They concluded that the results argue for increasing research into spatial cost-benefit analysis for conservation, so that economic information can complement the biodiversity layers typically used in conservation planning.

Norton-Griffiths & Southey (1995) estimated the opportunity costs of biodiversity conservation in Kenya from the potential net returns of agricultural and livestock production, and compared them with the net returns from tourism, forestry and other conservation activities. They adopt an essentially financial and partial equilibrium approach for a single year 1989 in which opportunity costs were compared with net benefits from tourism and forestry and found that at the national level, agricultural and livestock production in the parks, reserves and forests of Kenya could

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support 4.2 million Kenyans and generate gross annual revenues of $565 million and net returns of $203 million. These forgone net returns of $203m represented the opportunity cost to Kenya of biodiversity conservation. The study indicated that the current combined net revenues of $42 million from wildlife tourism and forestry were quite inadequate to cover these opportunity costs to land. The conclusion was that the government of Kenya was clearly subsidising conservation activities whose chief values were all indirect and external to Kenya.

2.4 Research Gap

Numerous studies have assessed the contribution of ecosystems to social and economic well-being and found that ecosystems form part of the total wealth of nations and contribute to the flow of benefits, including social and cultural. A significant amount of research and practical evidence has shown that wildlife resources have economic comparative advantage, i.e. are of high value to the people living in and around many savanna ecosystems and wildlife protection generates a wide range of valuable ecosystem services. Meanwhile there are studies in Kenya suggesting that Kenya is paying a very high price for its wildlife-based tourism (Norton-Griffiths & Southey, 1995; Norton-Griffiths, 2000 & Pearce, 1996). The basic choice facing Kenya's policy makers is to at least be aware of the cost of such incentives and thus make informed choice as to whether to continue with wildlife protection. Although biodiversity conservation has received considerable attention in research and policy circles in Kenya recently, rigorous empirical work on the subject of assessing the comparative economics of biodiversity conservation vis-à-vis the benefits forgone or realisable from alternate land use options of wildlife protected areas is lacking, thus the need to undertake country specific research. It is the intention of the present study to contribute to this literature in a number of ways.

Theory provides ambiguous predictions concerning. First is that societies rely directly or indirectly on wilderness but its value is predominantly implicit rather than explicit. Secondly, the question of whether endangered wildlife species protection has positive net present values and is thus a worthwhile action which should be supported by most governments. This paper is intended as a means of introducing stakeholders involved in wildlife protection decision making process and draws upon this past literature to propose a general methodological framework and terminology for integrating economic analysis techniques within the realm of endangered species protection. It is needed to make sound economic decisions about conserving biodiversity because the resource constraints policy makers operate under are severe.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter justifies the methodological approach, including data collection and analytical techniques; use of quantitative and qualitative methods; choice of research approach and paradigm; how the data was analysed. It focuses on the research design; estimation model or model specification and definition and measurement of variables; study area; target population; data and data collection procedures.

3.2 Research Design

This section sought to connect the conceptual research problem to the pertinent (and achievable) empirical research. The section articulates the required data, the methods used to collect and analyse the data, and how each research question is answered. This study design was descriptive and examined the economic rationale for the protection of endangered wildlife species. Gray (2004) acknowledges that the purpose of a descriptive study is to provide a picture of a phenomenon as it naturally occurs, maybe purely descriptive or it may also comprise a normative study, comparing the data against some standard.

3.3 Study Area

The Area of study was Nairobi National Park in Kenya. The park is the first national park to be established in East Africa in 1946, located approximately seven kilometers (7 km) south of the centre of Nairobi City, with an area of about 117.21 km^2, altitude ranges of between 1, 533 metres and 1, 760 metre and with a mean annual rainfall estimate of around 800 millimetre. Nairobi National Park boasts a large varied wildlife population and it is one of Kenya's most successful rhinoceros sanctuaries but has been affected by poaching. Furthermore, the park's boundary south is not fenced and is open to the Kitengela Community Area and the Athi-Kapiti plains and there is considerable movement of large ungulate species across this boundary.

3.4 Target Population

Target population refers to population about which an investigator wishes to draw a conclusion. Most policies or programmes implementation affects large and diverse population and may sometimes reduce the welfare of at least one person. Likewise wildlife protection policy or programmes by precluding close communities the right to the use of land for other productive

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activities, it can harm some individuals while benefiting others. Thus, the study focused mainly on equipping conservationists and policy makers with knowledge on the importance of regulating endangered species and their habitat. The focus was extended to include communities adjacent of Nairobi National Park, who are affected by the implementation of wildlife regulatory programmes in considering the view that strongly linked to policy design and development is the fact that policies must be operational in a way which unequivocally work for wildlife and local landholders. Thus wildlife protection policy must generate benefits at the village level in line with ‘Vision 2030’, read together with ‘The wildlife Conservation and Management Act, 2013’.

3.5 Study Species

Brown Jr & Shogren (1998) acknowledged that thinking about valuing a species is hard enough: valuing a complex combination of many species and their interactions within the context of a certain location, an ecosystem, generally should be more difficult. The endangered species, rhinoceros, herein referred as study species was selected given that they are Keystone species, the most poached, listed in the Forth Schedule of ‘The Wildlife Conservation and Management Act, 2013’ and have been the focus of international attention, i.e. specified in Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the International Union for Conservation of Nature and Natural Reserves – IUCN Red list status since it became known that their population had declined largely due to poaching for the rhinoceros horn. All commercial international trade in rhinoceros and their products and derivatives is prohibited and governments are required to implement wildlife protection policies aimed at providing a means whereby the ecosystems upon which endangered and threatened species depend may be conserved.

3.6 Data Sources and Data Collection Procedure

The research was based on extensive literature evaluation. Quantitative data collected for this study is as reflected in results table 4.1. The study use secondary information. Secondary information on benefits and costs of wildlife protection required for this study and information gaps were identified through collection from both published papers and papers quoted in published sources of combined valuation studies. These studies had to be published in peer-reviewed journals to avoid unknown and inaccessible studies. The study respondents included conservationists and research experts.

3.7 Cost-benefit Analysis

CBA is the implicit or explicit assessment of the social benefits and costs associated with a particular choice. The standard justification in respect of wildlife protection is on net benefit

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(NB) or net present value (NPV) grounds. It addresses the issue of whether overall the policy has a positive effect on society, or the social benefits (SB) of the policy outweigh the social costs (SC). It is calculated as a change in net social benefits to society, reflecting the total discounted social benefits minus total discounted social costs (i.e. annual flows of estimated economic values are often discounted to the present). The NB or NPV of the wildlife protection policy in practice is given by $(SB–SC) and this represents the extent to which having to protect wildlife is a better (SB–SC>0) or worse (SB–SC<0) use of scarce resources than the best alternative. This calculation of present value is descriptive of relative costs and benefits and allows direct comparison of policies with different annual flows of economic returns and possibly different policy time horizons. A NPV provides a value < 0, 0, or > 0, which indicates that benefits are smaller or equal to or larger than the costs expended to preserve or recover endangered species, respectively. Discounting the resulting list of net benefit, preferable by making use of a social discount rate in public decision-making, as opposed to a market rate, takes into account the greater value placed on money available today rather than later. NPV is useful for determining whether a given protection policy should go ahead because the main purpose of CBA is to demonstrate that meeting the protection target does not entail 'excessive' costs. Thus, so long as the present value of social costs is equal to the present value of social benefits, it cannot be argued that the costs are excessive. Thus it is recommended that the options with zero NPV should be accepted.

3.8 Cost-Benefit Analysis Valuation Approach

The study utilised the unit value transfer method which use existing values as an approximation by estimating total social benefits and costs at the policy site by aggregating exiting standard values per unit and transferring estimates from a site where a valuation study has been conducted to a site of policy interest (Kroeger, et al., 2008; Pearce, et al., 2006; Revesz & Stavins, 2004; Bateman, et al., 2003; & Elliott, et al., 2001). The process is termed pooling, involves taking data from different valuation methods and using the combined data to estimate a single model of preferences. Benefit or value transfer was essential to provide a proxy for the anticipated impact. Economic estimates were transferred as monetary value units by making use of the unadjusted unit transfer, the easiest approach to transferring benefit estimates from one site to another site of interest.

3.9 Cost-Benefit Analysis Model Specification

The study utilised the framework by Pearce, et al. (2006) and Campbell & Brown (2003) with several modifications. The net present value estimation: entailed enumeration of all benefits and costs to relevant social groups and borne by wildlife protection; and used discounting where

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relevant to derive present values; and looked at the distributive impact of the options into the future time. Accordingly, a four step analysis was important for this study.

Step 1: Enumerate benefits and Costs

Whose benefits and costs are to be counted? The basic rule was that benefits and costs to society should be included. A list of the benefits and costs was created (refer to Tables 4.1 and 4.2) derived from rhinoceros protection area, making use of the approach by Demir, (2013) which is based on a combination of valuation techniques. The study captured benefits expected in a future period as well as the present, effects on others and on society as a whole, and non-monetary as well as financial benefits and costs. However, consideration was made not to include benefits and costs with transfer element in the analysis on the grounds that they just offset each other (Hardisty, 2010; Loomis, 2000).

Step 2: Discounting

The costs and benefits of regulation are often realised in the future, requiring their numeric estimates to be discounted to obtain their present value (PV), i.e. treated as equivalent to small amounts of money today using a discount rate which is assumed to be the rate of interest. Pearce, et al., (2006) highlighted that discounting of future benefits and costs is thus determined by the rate at which individuals express time preference because individual preferences count as long as individuals prefer now to later and this value judgment must be applied to time. The present values of benefits (**B**) and costs (**C**) were calculated as follows:

$$\boldsymbol{PV(SB_t) = SB_t[(1-i)^{-t}]} \quad \textbf{(1)}$$

$$\boldsymbol{PV(SC_t) = SC_t[(1-i)^{-t}]} \quad \textbf{(2)}$$

With $\boldsymbol{(1-i)^{-t}}$ pronounced as the discounting factor.

Step 3: Impacts and time horizons

Benefits and cost are realised over time. Future time horizon was determined by simulation to identify the impacts of policy. The process involved the estimation of rhinoceros population growth geometrically or exponentially. First the researcher had to apply simple ceiling model which allows population growth to be exponential up to a ceiling that cannot be exceeded (applicable to cases where space is limited). The model used was that developed by Thomas Malthus which postulates that the abundance of a population (N) at time (t+1) is a function of both abundance at time t and the population growth rate:

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$$N_{t+1} = N_t\lambda \tag{3}$$

Where **λ:** lambda is the growth rate of population over discrete time steps describing the abundance (number of animals) next year as a multiple of abundance this year, regress $\mathbf{N_t}$ is the initial species population at base time, and $\mathbf{N_{t+1}}$ is the species population at the time variable **t** known as the trend variable or the future time period of study focus. If the slope coefficient is positive, there is an upward trend in **N**, whereas if it is negative, there is a downward trend in **N**. Our interest is on determining $\mathbf{t^*}$ optimal density population which can be accommodated in area allocated for conservation to wildlife. The simplified version of the formula is as follows:

$$\frac{\partial N}{\partial t} = rN\left(1 - \frac{N}{K}\right)\left(\frac{N}{A} - 1\right) \tag{4}$$

Where ***r*** is the instantaneous growth rate per capita (per individual), ***N*** is the optimal species population, **A** is range land area, and **k** is the land carrying capacity. Thereafter applied the geometric or exponential model where the current population was multiplied by a constant number each time step. ***r*** was determined as per the formula below:

$$r = \ln \lambda \tag{5}$$

The ***ln*** is the natural logarithm, with the base ***e***.

Step 4: Comparison/Net Social Benefit

A complete **CBA** compares alternative actions, i.e. compare the sum of the discounted benefits produced by the alternative to the discounted costs incurred by the alternative to determine which one provides society with the greatest net benefits through the most economically efficient use of its resources (Loomis & Helfand, 2003). The study utilised the 'With and without proposed intervention approach' principle. To calculate a program's net present value **(NPV)** or net social benefit **(NSB)**, the present values of all its costs and benefits over time were added which measured how much the policy increases wealth. The basic rule governing an individual's choice of an action is based on whether the benefits outweigh the costs. The necessary condition for the adoption of a policy is that discounted social benefits should exceed discounted social costs based on the formula below:

PV (SB)>PV (SC) or, **NPV>0** **(6)**

Net Social Benefit (NSB) = SB – SC > 0

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Where **PV(SB)** refers to the (gross) present value of social benefits, **PV(SC)** refers to the gross present value of social costs and **NPV** refers to the net present value (or present value of net benefits) so that: **NPV** = **PV(SB)** – **PV(SC)** with present values calculated at the social discount rate.

The **NPV** is calculated as follows:

$$\boldsymbol{NPV = \Sigma SB_t[(1-i)^{-t}] - \Sigma SC_t[(1-i)^{-t}]} \qquad \textbf{(7)}$$

Where: $\mathbf{SB_t}$ is the social benefit at time **t**; $\mathbf{SC_t}$ is the social cost at time **t**; and $\boldsymbol{i}$ is the discount rate.

The net present value **(NPV)** criteria states that a **NPV** of greater than zero is accepted as economically efficient. Meanwhile a negative **NPV** means society gives up more than it gets over the life of the resource management action.

3.10 Validity and Reliability

Reliability of data is the consistency of measures in a study based on the degree to which research instruments yields consistent results. It is an evaluation of whether the transfer estimates and the original estimates at the policy site, both supposedly measuring the same value concept, actually converge. The study mostly sourced information of value relating to African situation considering that the validity of a value transfer will be higher if the good that was valued in the source study was similar to the good that was to be changed at policy site, in terms of the definition of the good itself, the degree to which it will change, and the population affected. Additionally experts' advice was sought and recommendation incorporated accordingly.

3.11 Data Processing and Data Presentation

Data was analysed through the use of spreadsheet (excel). All data collected on a spreadsheet with the major costs and benefits presented with the key results on tables. The value estimate was adjusted from the time of data collection to current currency using the appropriate discount rate for the policy.

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CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the analysis of the data collected from both published papers and papers quoted in published sources of combined valuation studies and discusses the research findings. Data listing is presented first followed by findings on social benefits and costs of rhinoceros protection.

The main objective of conservation management of endangered species is to minimise the probability of population decline or extinction, or conversely, to maximise the probability of population persistence. Decision making usually involve trade-off. In this analysis we highlight the trade-off between protecting endangered species and doing nothing, i.e. "with or without endangered species protection". Accordingly there has to be justification on restricting endangered species in protected areas, thus the questions of what stand to be benefited and the opportunity costs associated with restricting the areas from local community use. To assess whether endangered species regulation is a worthwhile endeavours, the researcher needed to compute in monetary value (US$) the net benefits arising from endangered species protection action. The distribution of social benefits and costs was tracked, expressed in common units, US$/ha of land area, to adjacent communities of the Nairobi National Park given that the local communities bears the bulk of the opportunity costs associated with the existence of the park. The present values of the benefits of the policy were added up and then compared with their costs.

4.2 Results

The calculated measures of the study analysis are exhibited in the tables: Table 4.1 – Table 4.4 that follow. Further detailed calculations to produce the results are shown in the appendix tables, Table A1 – Table A9.

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Table 4. 1: Data Listing for Cost-benefit Analysis

Author	Value Category	Use Category	Value	Year
(Elliott, et al., 2008)	Trophy Hunting	Direct-Use Value	\$7.20/ha/year	1998
(Ferraro, et al., 2011)	Selected range of marketed products	Direct-Use Value	\$ 5/ha/year	1997
(Bagine, 2003)	Recreation & Tourism Value	Indirect-Use Value	\$47,545,369.83 / 117.21 Km^2	2002
(Ferraro, et al., 2011)	Carbon Regulation	Indirect-Use Value	\$ 378/ha/year	2006
(Demir, 2013)	Water Regulation	Indirect-Use Value	\$ 273/ha/year	1999
(Ferraro, et al., 2011)	Pollination	Indirect-Use Value	\$ 63/ha/year	2007
(Norton-Griffiths & Southey, 1995)	Opportunity Cost	Option-Value	\$99 million/41,420Km^2	1989
T/S	Legal Fines/Auction Rhino Price	Non-Use (Existence/Bequest) Values	\$ 1, 330,94	2015
(Ninan, et al., 2007)	Medicinal Value	Direct-Use Value	\$3,327/ha/year	1992
(Norton-Griffiths & Southey, 1995)	Opportunity Cost		\$99 million/41,420Km^2	1989
(Olweny, 2011)	Discount Rate		6%	

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Table 4. 1: Data Listing for Cost-benefit Analysis (continued)

Author	Value Category	Use Category	Value	Year
T/S	Rhino Population		66	2014
(Penny, 2001)	Density		0.4 Rhino/km^2	2001
(Koopmans, 2012) & (Emslie, et al., 2012)	Growth Rate		6.9%	2010
T/S	Area		117.21 Km^2	2015

Table 4. 2: Discounting Benefits and Costs at 6% discount rate to obtain Present Values

Value Category	Base Year (Y_t)	No. of Years to Y_{t+1}	Discounting Factor	Initial Value (US$)	Present Value (US$)
Tourism Earnings	2002	14	0.44	51.84	**22.93**
Carbon Regulation	2006	10	0.56	378.00	**211.07**
Pollination	2007	9	0.59	63.00	**37.29**
Water Regulation	1999	17	0.37	273.00	**101.38**
Trophy Hunting	1998	18	0.35	7.20	**2.52**

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Medicinal Value	1992	24	0.41	3,327.00	**1,349.85**
Legal Fines/Auction Rhino Price	2015	-	-	-	**1,330.94**
Opportunity Cost	1989	27	0.21	68.81	**(14.27)**

Table 4. 3: Density - Dependent Population Change

Year	**Population N_t**	**Growth Rate (λ)**	**Geometric Growth Rate (λ_t)**	**Population (N_{t+1})**	**Carrying Capacity (K)**	**Total Area (A)**	**Population Production / Recruitment (*d*N*d*t)**
2015	66	0.069	1	66	0.4	117.21	**0**
2016	66	0.069	1.07	71	0.4	117.21	**329**
2017	71	0.069	1.14	75	0.4	117.21	**673**
2018	75	0.069	1.22	81	0.4	117.21	**1010**
2019	81	0.069	1.31	86	0.4	117.21	**1306**
2020	86	0.069	1.40	92	0.4	117.21	**1508**
2021	92	0.069	1.49	98	0.4	117.21	**1544**
2022	98	0.069	1.60	105	0.4	117.21	**1311**
2023	105	0.069	1.71	113	0.4	117.21	**669**
2024	113	0.069	1.82	120	0.4	117.21	**(575)**

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Table 4. 4: Projecting Benefits and Costs over the Life of the Policy at 6% discount rate (Lindsey, et al., 2007 & Loomis & Helfand, 2003)

YEAR	2015	2016	2017	2018	2019	2020	2021	2022	2023
DISCOUNT FACTOR	**0.94**	**0.89**	**0.83**	**0.79**	**0.74**	**0.70**	**0.66**	**0.63**	**0.59**
BENEFITS:									
CARBON REGULATION	199.12	187.85	177.22	167.19	157.72	148.80	140.37	132.43	124.9
LEGAL FINES/RHINO ACTION PRICE	1,330.94	1,330.94	1,330.94	1,330.94	1,330.94	1,330.94	1,330.94	1,330.94	1,330
POLLINATION	35.18	33.19	31.19	29.54	27.87	26.29	24.80	23.40	22.07
TOURISM EARNINGS	21.63	20.41	19.25	18.16	17.13	16.16	15.25	14.39	13.57
WATER REGULATION	95.64	90.23	85.12	80.30	75.76	71.47	67.42	63.61	60.01
TROPHY HUNTING								1.58	1.49
MEDICINAL VALUE								515.54	486.3
COSTS:									
OPPORTUNITY COST	(13.46)	(12.70)	(11.98)	(11.30)	(10.66)	(10.06)	(9.49)	(8.95)	(8.45
NET PRESENT VALUE	**1,669.06**	**1,649.92**	**1,631.86**	**1,614.83**	**1,598.76**	**1,583.60**	**1,569.30**	**1,555.81**	**2,031**

4.3 Discussion

The law ('The Wildlife and Management Act, 2013') requires that wildlife conservation and management shall be exercised in accordance with the principles of sustainable utilisation to meet the benefits of present and future generation. In line with the law requirement, the analysis projected future flows of social benefits and costs through discounting them and then applying the decision criteria to decide whether the policy is worthwhile. The primary benefit resulting from wildlife protected area regulation is the increased stability of wildlife populations, adding to biodiversity, leading to better natural control of invasive species introductions, and increased land devoted to native wildlife habitats, including forestland, grasslands, wetlands, and other

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terrestrial and aquatic habitats. Additionally, the effects brought about by the policy on protection of endangered species include amongst others: enjoyment from the presence of wildlife on land, monetary benefits through various wildlife recreational activities such as hunting, bird watching, and other eco-tourism activities, climate regulation, flood control, disease prevention, water purification, carbon sequestration, biodiversity, and a host of other environmental benefits.

4.3.1 Data listing for cost benefit analysis in monetary terms

Table 4.1 presents a listing of the benefits derived from protection of endangered species and the associated opportunity cost (forgone benefit of undertaking wildlife protection) in monetary (US$/ha) terms because in cost-benefit analysis (CBA), benefits and costs are measured, as far as possible, in monetary terms. Basically, our analysis first identifies the positive and negative social consequences of the policy, i.e. the social benefits and costs. A wildlife protection policy generates a variety of benefit categories into use and non-use values as follows: (i) ‘goods’ (i.e., products obtained from ecosystems, such as resource harvests, water and genetic material); (ii) ‘services’ (i.e., recreational and tourism benefits or certain ecological regulatory functions), such as water purification, climate regulation, erosion control, etc.; and (iii) cultural benefits (i.e. spiritual and religious, heritage, etc.). However, conservation plans cannot be implemented for free, they may have negative impact on livelihoods of inhabitants, they have associated costs, which cover everything that must be given up to implement the intervention and this may results in ineffectiveness of the intended policy. From a social perspective, economists use opportunity costs, a measure of what could have been gained via the next-best use of a resource had it not been used for the current use (Hanley & Barbier, 2009 & Naidoo, et al., 2006).

4.3.2 Present values of social benefits and social cost

Table 4.2 shows the social values of benefits and costs discounted to obtain its present values. The degree to which an economically valuable biological resource should be exploited is driven by the social discount rate, a method for determining how to split the stock of natural capital between consumption now and consumption in the future (Gowdy, et al., 2010). In CBA, when a benefit or cost happen in any period other than the period in which the analysis is being undertaken (base year 0), the social values of benefits and costs must be discounted, using a discount factor $\mathbf{(1+\mathit{i}^{)-t)})}$, to obtain its present value. The discount factor utilises the rate of interest (***i***), the rate at which society weighs future consumption against present consumption. The net present value arises out of the time value of money, or time preference. The study uses the real rate of return on private capital to compare future and present values. One typical study (Olweny, 2011) estimated such rates of returns at between 6% and 9%. Literature discourages the use of a

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higher discount rate and sights that it can lead to the long-term degradation of biodiversity and ecosystems.

4.3.3 Future Time Horizon

The Table 4.3 provides an analysis of the species population abundance, undertaken to select a suitable time horizon, i.e. the time frame of social benefits and costs in the analysis. This emanates from the fact that endangered species protection policy causes 'inter-temporal' changes in wildlife population over time, which necessitates the modelling of the 'dynamic' changes on both present and future flows of social benefits and costs. The future flows of social benefits and costs was guided by population growth assumption. Population growth refers to any trajectory in abundance over time, including increases, decreases, or no change (Mills, 2007). The analysis showed that at annual population growth rate of 6.9% ($\boldsymbol{r}$ = 0.069) and area of 117.21 km^2, positive density-dependence dominates (increases at an increasing rate) until net growth rate is maximised at population size of approximately ninety eight (98) species in the year 2021. Thereafter, the rate of population growth increases at a decreasing rate until net growth rate zero is reached between 2023 and 2024, at a population of 117 species, the maximum species population the area can accommodate. At that point in time rhinoceros population will equal carrying capacity, $\boldsymbol{dN_t/dt}$ equals zero, meaning that beyond 2023, population becomes greater than carrying capacity, resulting in negative feedback. Accordingly harvesting plans need to be put in place to control further population net growth rate decline (further increases in population) and have a sustainable or healthy productive population. Dividing 98 species which is the optimal species population by 117 species, the maximum species population the area can take, gives around 83% a figure that promotes rhinoceros productivity, preventing density dependent declines in rhino breeding performance and increases in mortalities.

4.3.4 Comparing Social Benefits and Social Costs

Table 4.4 shows an analysis of the distribution of the discounted social benefits and costs over the life of the policy. From the cost benefit analysis perspective a management approach would be considered worthwhile if it generates net positive contribution to society regardless of the distribution of social benefits and costs. To effectively capture the incremental benefit due to a given course of action, the benefits arising from such action are compared with what would occur without the action (baseline scenario). The study used the *"with and without"* analysis, and used the opportunity cost as the baseline scenario comparing it with the calculated identified incremental benefits. The basic rule is not to sanction anything where the costs exceed the benefits. The **NPV** analysis showed that in all varying time horizons the wildlife protection policy, given by **\$(SB–SC)** was a better **(SB–SC$\geq$0)** use of scarce resources than the best

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alternative. It meant that having to protect endangered species potentially generates positive net social benefits per unit area of land over the life of the policy, indicating that engaging in protection action of the parks is a worthwhile endeavor. Also worth noting from the analysis is the fact that the policy prohibit any production activity until sometime in the future, meaning benefits as such those derived from sale of goods and trophy hunting can only be attained in the future period when it becomes fit to harvest species, that would be for decision makers to choose between year 2021 and 2023.

CHAPTER 5

CONCLUSION

5.0 Introduction

This chapter presents the summary, conclusion and recommendation of the study carried out.

5.1 Summary

The purpose of the study was to foster improved support of wildlife protection programs on eligible lands. The study first examined if endangered wildlife species regulation was achieved at least loss of economic well-being (i.e. social benefits are more than social costs) and secondly, because endangered species protection has impacts over extended period of time, the study looks at approaches to sustainable use and management of endangered species in protected areas. Economic analysis, especially cost-benefit analysis is needed because it has the potential of addressing several barriers to adopting conservation practices. In environmental regulation, cost-benefit analysis plays a key role in determining how to achieve our environmental goals without imposing unnecessary costs on the economy.

The researcher has presented empirical evidence with regard to the economics of rhinoceros management using as a case study Nairobi National Park. The worthiness of endangered species protection was analysed using the net present value **(NPV)** test, with density-dependent feedback mechanism providing insight into the population dynamics and interaction of rhinoceros with their ecosystem to inform on the future period on which endangered species protection policy should be exercised. The study assessed the distribution of social benefits and costs of endangered species protection, considered how social benefits and costs varied in light of alternative regulation and their distribution over the life of the policy.

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5.2 Conclusion

The empirical analysis found two interesting results. Firstly, wilderness preservation generates positive net social benefits per unit area of land over the life of the policy as the benefits accruing to society from protecting endangered wildlife species from becoming extinct exceed the costs associated with the policy. It indicates that engaging in protection action of Nairobi National Park could be a worthwhile endeavor, meaning the policy is worth undertaking and should be promoted. Secondly, the density-dependent population dynamics which informs the future time horizon on which to focus protection efforts indicated that an optimal rhinoceros population which Nairobi National Park could accommodate can be realised by the period year 2021. This is the optimal time period which ensures sustainability, meets the needs of the present wildlife population without compromising the ability of future wildlife generation to meet their own needs. Beyond this period, harvesting plans need to be implemented to control further rhinoceros population increases which may lead to decline in rhinoceros population and ensure that Nairobi National Park has a healthy productive population. Because the policy on protection of endangered species prohibit any production activity until sometime in the future, benefits such as sale of goods and trophy hunting can only be attained in the future period when it becomes fit to control further increases in rhinoceros population, be it through translocation to areas or through harvesting species, that would be for decision makers to choose. The analysis build on the assumption that society can obtain a wide range of benefits compared to the opportunity cost of restricting land use by local communities within their proximity and that if properly distributed can provide real contribution to human welfare. It is also argued that protecting endangered species should not be indefinitely, at some species population levels, measures to control further population increases need to be applied.

5.3 Recommendation

The study finds that policy decisions on wildlife management should have a time dimension because it involves sacrificing current consumption for future satisfaction. Furthermore, the study finds that social benefits and costs of wildlife protection occur at differing time horizon and policy specific conditions should dictate the appropriate time horizon upon which to conduct an economic analysis, that is, tailor the time frame to capture all benefits and costs likely to arise from the policy. According to this study, it is only beneficial for specific policy protection of the rhinoceros at the Nairobi National Park be exercised up to the year 2021, since beyond this time, it is a must to harvest, to control further increases in population or do a translocation from the park.

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5.4 Suggestions for Further Research

However, this study may not be complete as it is. Firstly, it ignores the fact that other forms negative density-dependent, or positive density-dependent would lead to different predictions. Secondly, while there are some efforts to safeguard wildlife, benefits distribution is a necessity. Studies have shown that payments of compensation to communities within proximity of protected area can positively stimulate people towards supporting wildlife protection. However, realising the benefits to livelihood still faces challenges due to lack of policy instruments that may benefit individuals affected by the conservation policy. Accordingly further ecological/economic studies should be undertaken to establish more accurate attribution and encompass the entire wildlife population in Kenya and their direct economic impact. It is important to move beyond merely extrapolating that conserving wildlife positively contributes to national economic goals but the extent to which wildlife benefits actually reach the local resident in proximity to protected areas.

DEDICATION

The research work is dedicated to the following:

Firstly, my late father, Mr. Benjamin Fanukwente Mndokolo Mhlabane for his passion and endless support for my education profession. May his soul rest in eternal peace.

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APPENDIX

Table A1: Discounting Auction Price at 6% discount rate to obtain Present Values

year		Nominal	Discounting Factor	Net Present Value
1998	1	7.20	0.94340	6.79
1999	2	7.20	0.89000	6.41
2000	3	7.20	0.83962	6.05
2001	4	7.20	0.79209	5.70
2002	5	7.20	0.74726	5.38
2003	6			

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		7.20	0.70496	5.08
2004	7	7.20	0.66506	4.79
2005	8	7.20	0.62741	4.52
2006	9	7.20	0.59190	4.26
2007	10	7.20	0.55839	4.02
2008	11	7.20	0.52679	3.79
2009	12	7.20	0.49697	3.58
2010	13	7.20	0.46884	3.38
2011	14	7.20	0.44230	3.18
2012	15	7.20	0.41727	3.00
2013	16	7.20	0.39365	2.83
2014	17	7.20	0.37136	2.67
2015	18	7.20	0.35034	2.52
			Sum PV	**77.96**

Year		Nominal	Discounting Factor	Net Present Value
2015	1	2.52	0.94340	2.38
2016	2	2.52	0.89000	2.24
2017	3	2.52	0.83962	2.12
2018	4	2.52	0.79209	2.00
2019	5	2.52	0.74726	1.88
2020	6	2.52	0.70496	1.78

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2021	7	2.52	0.66506	1.68
2022	8	2.52	0.62741	1.58
2023	9	2.52	0.59190	1.49
			Sum PV	**17.14**

Table A2: Discounting Tourism Earnings at 6% discount rate to obtain Present Values

Year		Nominal	Discounting Factor	Net Present Value
2007	6	51.84	0.70496	36.55
2008	7	51.84	0.66506	34.48
2009	8	51.84	0.62741	32.53
2010	9	51.84	0.59190	30.68
2011	10	51.84	0.55839	28.95
2012	11	51.84	0.52679	27.31
2013	12	51.84	0.49697	25.76
2014	13	51.84	0.46884	24.30
2015	14	51.84	0.44230	22.93
			Sum PV	**481.86**
2015	1	22.93	0.94340	21.63
2016	2	22.93	0.89000	20.41
2017	3	22.93	0.83962	19.25
2018	4	22.93	0.79209	18.16
2019	5	22.93	0.74726	17.13
2020	6	22.93	0.70496	16.16

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2021	7	22.93	0.66506	15.25
2022	8	22.93	0.62741	14.39
2023	9	22.93	0.59190	13.57
			Sum PV	**155.96**

Table A3: Discounting Carbon Regulation at 6% discount rate to obtain present values

Year		**Nominal**	**Discounting Factor**	**Net Present Value**
2006	1	378.00	0.94340	356.60
2007	2	378.00	0.89000	336.42
2008	3	378.00	0.83962	317.38
2009	4	378.00	0.79209	299.41
2010	5	378.00	0.74726	282.46
2011	6	378.00	0.70496	266.48
2012	7	378.00	0.66506	251.39
2013	8	378.00	0.62741	237.16
2014	9	378.00	0.59190	223.74
2015	10	378.00	0.55839	211.07
			Sum PV	**2,782.11**
2015	1	211.07	0.94340	199.12
2016	2	211.07	0.89000	187.85
2017	3			

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		211.07	0.83962	177.22
2018	4	211.07	0.79209	167.19
2019	5	211.07	0.74726	157.72
2020	6	211.07	0.70496	148.80
2021	7	211.07	0.66506	140.37
2022	8	211.07	0.62741	132.43
2023	9	211.07	0.59190	124.93
			Sum PV	**1,435.63**

Table A4: Discounting Pollination at 6% discount rate to obtain present values

Year		**Nominal**	**Discounting Factor**	**Net Present Value**
2007	1	63.00	0.94340	59.43
2008	2	63.00	0.89000	56.07
2009	3	63.00	0.83962	52.90
2010	4	63.00	0.79209	49.90
2011	5	63.00	0.74726	47.08
2012	6	63.00	0.70496	44.41
2013	7	63.00	0.66506	41.90
2014	8	63.00	0.62741	39.53
2015	9	63.00	0.59190	37.29
			Sum PV	**428.51**

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2015	1	37.29	0.94340	35.18
2016	2	37.29	0.89000	33.19
2017	3	37.29	0.83962	31.31
2018	4	37.29	0.79209	29.54
2019	5	37.29	0.74726	27.87
2020	6	37.29	0.70496	26.29
2021	7	37.29	0.66506	24.80
2022	8	37.29	0.62741	23.40
2023	9	37.29	0.59190	22.07
			Sum PV	**253.64**

Table A5: Discounting Water Regulation at 6% discount rate to obtain present values

Year		**Nominal**	**Discounting Factor**	**Net Present Value**
1999	1	273.00	0.94340	257.55
2000	2	273.00	0.89000	242.97
2001	3	273.00	0.83962	229.22
2002	4	273.00	0.79209	216.24
2003	5	273.00	0.74726	204.00
2004	6	273.00	0.70496	192.45
2005	7	273.00	0.66506	181.56

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2006	8	273.00	0.62741	171.28
2007	9	273.00	0.59190	161.59
2008	10	273.00	0.55839	152.44
2009	11	273.00	0.52679	143.81
2010	12	273.00	0.49697	135.67
2011	13	273.00	0.46884	127.99
2012	14	273.00	0.44230	120.75
2013	15	273.00	0.41727	113.91
2014	16	273.00	0.39365	107.47
2015	17	273.00	0.37136	101.38
			Sum PV	**2,860.29**

Year		Nominal	Discounting Factor	Net Present Value
2016	2	101.38	0.89000	90.23
2017	3	101.38	0.83962	85.12
2018	4	101.38	0.79209	80.30
2019	5	101.38	0.74726	75.76
2020	6	101.38	0.70496	71.47
2021	7	101.38	0.66506	67.42
2022	8	101.38	0.62741	63.61
2023	9	101.38	0.70259	71.23
			Sum PV	700.78

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Table A6: Discounting Trophy Hunting at 6% discount rate to obtain present values

Year		Nominal	Discounting Factor	Net Present Value
1998	1	7.20	0.94340	6.79
1999	2	7.20	0.89000	6.41
2000	3	7.20	0.83962	6.05
2001	4	7.20	0.79209	5.70
2002	5	7.20	0.74726	5.38
2003	6	7.20	0.70496	5.08
2004	7	7.20	0.66506	4.79
2005	8	7.20	0.62741	4.52
2006	9	7.20	0.59190	4.26
2007	10	7.20	0.55839	4.02
2008	11	7.20	0.52679	3.79
2009	12	7.20	0.49697	3.58
2010	13	7.20	0.46884	3.38
2011	14	7.20	0.44230	3.18
2012	15	7.20	0.41727	3.00
2013	16	7.20	0.39365	2.83
2014	17	7.20	0.37136	2.67
2015	18	7.20	0.35034	2.52
			Sum PV	**77.96**

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Year		Nominal	Discounting Factor	Net Present Value
2015	1	2.52	**0.94340**	**2.38**
2016	2	2.52	**0.89000**	**2.24**
2017	3	2.52	**0.83962**	**2.12**
2018	4	2.52	**0.79209**	**2.00**
2019	5	2.52	**0.74726**	**1.88**
2020	6	2.52	**0.70496**	**1.78**
2021	7	2.52	**0.66506**	**1.68**
2022	8	2.52	**0.62741**	**1.58**
2023	9	2.52	**0.59190**	**1.49**
			Sum PV	**17.14**

Table A7: Discounting Medicinal Value at 6% discount rate to obtain present values

Year		Nominal	Discounting Factor	Net Present Value
1992	1	3,327.00	0.96154	3,199.04
1993	2	3,327.00	0.92456	3,076.00
1994	3	3,327.00	0.88900	2,957.69
1995	4	3,327.00	0.85480	2,843.93
1996	5	3,327.00	0.82193	2,734.55
1997	6	3,327.00	0.79031	2,629.38
1998	7	3,327.00	0.75992	2,528.25

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1999	8	3,327.00	0.73069	2,431.01
2000	9	3,327.00	0.70259	2,337.51
2001	10	3,327.00	0.67556	2,247.60
2002	11	3,327.00	0.64958	2,161.16
2003	12	3,327.00	0.62460	2,078.03
2004	13	3,327.00	0.60057	1,998.11
2005	14	3,327.00	0.57748	1,921.26
2006	15	3,327.00	0.55526	1,847.37
2007	16	3,327.00	0.53391	1,776.31
2008	17	3,327.00	0.51337	1,707.99
2009	18	3,327.00	0.49363	1,642.30
2010	19	3,327.00	0.47464	1,579.14
2011	20	3,327.00	0.45639	1,518.40
2012	21	3,327.00	0.43883	1,460.00

year		Nominal	Discounting Factor	Net Present Value
2013	22	3,327.00	0.42196	1,403.85
2014	23	3,327.00	0.40573	1,349.85
			Sum PV	**49,428.71**
2014	1	1,349.85	0.96154	1,297.93

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2015	2	1,349.85	0.92456	1,248.01
2016	3	1,349.85	0.88900	1,200.01
2017	4	1,349.85	0.85480	1,153.86
2018	5	1,349.85	0.82193	1,109.48
2019	6	1,349.85	0.79031	1,066.81
2020	7	1,349.85	0.75992	1,025.78
2021	8	1,349.85	0.73069	986.32
2022	9	1,349.85	0.70259	948.39
			Sum PV	**10,036.58**

Table A8: Discounting Opportunity Costs at 6% discount to obtain present values

year		**Nominal**	**Discounting Factor**	**Net Present Value**
1989	1	68.81	0.94340	64.91
1990	2	68.81	0.89000	61.24
1991	3	68.81	0.83962	57.77
1992	4	68.81	0.79209	54.50
1993	5	68.81	0.74726	51.42
1994	6	68.81	0.70496	48.51
1995	7	68.81	0.66506	45.76
1996	8	68.81	0.62741	43.17
1997	9	68.81	0.59190	40.73

1998	10	68.81	0.55839	38.42
1999	11	68.81	0.52679	36.25
2000	12	68.81	0.49697	34.20
2001	13	68.81	0.46884	32.26
2002	14	68.81	0.44230	30.43
2003	15	68.81	0.41727	28.71
2004	16	68.81	0.39365	27.09
2005	17	68.81	0.37136	25.55
2006	18	68.81	0.35034	24.11
2007	19	68.81	0.33051	22.74
2008	20	68.81	0.31180	21.45
2009	21	68.81	0.29416	20.24

year		**Nominal**	**Discounting Factor**	**Net Present Value**
2010	22	68.81	0.27751	19.09
2011	23	68.81	0.26180	18.01
2012	24	68.81	0.24698	16.99
2013	25	68.81	0.23300	16.03
2014	26	68.81	0.21981	15.12
2015	27	68.81	0.20737	14.27
			Sum PV	

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				908.98
2015	1	14.27	0.94340	13.46
2016	2	14.27	0.89000	12.70
2017	3	14.27	0.83962	11.98
2018	4	14.27	0.79209	11.30
2019	5	14.27	0.74726	10.66
2020	6	14.27	0.70496	10.06
2021	7	14.27	0.66506	9.49
2022	8	14.27	0.62741	8.95
2023	9	14.27	0.59190	8.45
			Sum PV	97.06

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Table A9: Density-Dependent Population Dynamics

Year		Population - Nt	Growth Rate	λ	Population - N(t+1)	r	rN	K	A	(1-(N/K))	((N/A)-1)	rN(1-(N/K))((N/A)-1)
2015	0	66	0.069	1.00	66	-	-	0.4	117.21	(164.00)	(0.44)	**0**
2016	1	66	0.069	1.07	71	0.07	4.71	0.4	117.21	(175.39)	(0.40)	**329**
2017	2	66	0.069	1.14	75	0.13	10.06	0.4	117.21	(187.56)	(0.36)	**673**
2018	3	66	0.069	1.22	81	0.20	16.14	0.4	117.21	(200.57)	(0.31)	**1010**
2019	4	66	0.069	1.31	86	0.27	23.00	0.4	117.21	(214.47)	(0.26)	**1306**
2020	5	66	0.069	1.40	92	0.33	30.74	0.4	117.21	(229.34)	(0.21)	**1508**
2021	6	66	0.069	1.49	98	0.40	39.43	0.4	117.21	(245.24)	(0.16)	**1544**
2022	7	66	0.069	1.60	105	0.47	49.18	0.4	117.21	(262.23)	(0.10)	**1311**
2023	8	66	0.069	1.71	113	0.53	60.08	0.4	117.21	(280.39)	(0.04)	**669**
2024	9	66	0.069	1.82	120	0.60	72.25	0.4	117.21	(299.80)	0.03	**-575**

