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Draft Report

03 An Economic Assessment of Economic Services Provided by Vultures: A Case Study from the Kanha-Pench Corridor

THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY-INDIA INITIATIVE

FOREST

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THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY-INDIA INITIATIVE

Indo-German Biodiversity Programme

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- The Economics of Ecosystems and Biodiversity - India Initiative (TII)
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Responsible
JR Bhatt, Scientist-G, MoEFCC
Konrad Uebelhoer, Director, Indo-German Biodiversity Programme

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An Economic Assessment of Economic Services Provided by Vultures: A Case Study from the Kanha-Pench Corridor

N M Ishwar, IUCN, New Delhi
Saudamini Das, IEG, New Delhi
Jagriti Kumari, IUCN, New Delhi
Vibhu Prakash, BNHS, Mumbai
P R Sinha, IUCN, New Delhi

IMPLEMENTING PARTNER:

INTERNATIONAL UNION FOR CONSERVATION OF NATURE, INDIA
www.iucn.org/india

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Project Team

Associate: Ms Jagriti Kumari (IUCN India Office)

Lead Economic Consultant: Dr Saudamini Das (Institute for Economic Growth)

Advisors: Dr Vibhu Prakash (Deputy Director, Bombay Natural History Society) and Mr PR Sinha (IUCN India Office)

Principle Investigator: Dr N M Ishwar (IUCN India Office)

Field Support: Team at Mandla, Kanha-Pench Corridor – Foundation for Ecological Security

THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY-INDIA INITIATIVE

The Economics of Ecosystems and Biodiversity – India Initiative (TII) aims at making the values of biodiversity and linked ecosystem services explicit for consideration and mainstreaming into developmental planning. TII targets action at the policy making levels, the business decision level and awareness of citizens. TII has prioritized its focus on three ecosystems - forests, inland wetlands, and coastal and marine ecosystems - to ensure that tangible outcomes can be integrated into policy and planning for these ecosystems based on recommendations emerging from TII.

In addition to the existing knowledge, TII envisions establishing new policy-relevant evidences for ecosystems values and their relation to human well-being through field-based primary case studies in each of the three ecosystems. In response to an open call for proposals for conducting field-based case studies in the context of relevant policy or management challenges for conservation and the sustainable use of biodiversity and ecosystem services, over 200 proposals were received. A Scientific and Technical Advisory Group (STAG), comprising eminent ecologists and economists, appraised the proposals and recommended 14 case studies for commissioning under TII.

These studies in forests deal with issues such as hidden ecosystem services of forests, conflicts between humans and wildlife, and the economic consequences of species decline. In wetlands, the studies draw lessons on water resources management, community stewardship and equity, and the economics of hydrological regime changes. In coastal and marine ecosystems, the studies explore the opportunities and economic efficiency of interventions such as eco-labelling, seasonal fishing bans, mangrove regeneration, and the challenge of bycatch in marine fisheries.

The reports of these 12 case studies have been published in this TII series.

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12 Economic Valuation of Biodiversity Loss: A Study of By-Catch from Marine Fisheries in Andhra Pradesh

KEY MESSAGES

Indiscrimate veterinary use of Diclofenac, an anti-inflammatory drug, has resulted in severe decline in the number of Gyps vultures in India. This has meant that nature's primary scavengers have been removed from our landscapes. Who then will play the role of scavengers? In the urban scenario, municipalities will have to rethink whether it is economically sound to build a new waste management system to dispose of carcasses or breed and re-introduce vultures.

FINDINGS

- Present investment value required in carcass disposal services for the next 50 years in rural areas is estimated to be around **₹351.5 million** (**US$ 5.85m**).
- The scavenging ability of **300 pairs** of vultures is close to the processing potential of a medium carcass disposal plant i.e. approximately **60 carcasses** per week.
- It is economically prudent to invest in the breeding and re-introduction of vultures and maintenance of Vulture Safe Zones (VSZ) instead of investing in carcass disposal plants.
- There is a marginal price difference of **₹4** (**US$ 0.06**) per 30 ml vial in the cost of human Diclofenac and Indian formulations of Meloxicam. European formulation of Meloxicam is as effective as Diclofenac, but its price is significantly higher, **₹145** (**US$ 2.4**) per 30 ml vial.
- Despite the ban, Diclofenac continues to be used especially by para-vets, as they have little knowledge about the ban.

RECOMMENDATIONS

- Create a network of para-vets, villagers who promote the use of the safer Meloxicam in areas adjoining Protected Areas, and especially in and around areas of the seven proposed VSZs by the Government of India.
- Stronger and better monitoring is required of population increase in secondary scavengers and ungulate deaths due to feral dogs and other secondary/ obligate scavengers.
- Continue efforts in ex-situ Vulture conservation and recovery.

Photo: IUCN

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1. Case study background

Vultures have historically been recognised for their ability to rapidly feed on carcasses and their role in the ecosystem as a successful primary scavenging species. Presently, 14 out of 23 vulture species are threatened to extinction; a majority of these are from Asia. Recently, vulture populations have been observed to have declined by over 99% and three of the Gyps species of vultures have shown a drastic reduction in population (SAVE 2014a). Road transect surveys have shown a 99% decline in the population of the Oriental White-backed vulture, while the Slender-billed vulture and Long-billed vulture showed a combined decline of 96.8% (Prakash et al. 2007). Once numbering in tens of millions, the combined population of these three species have now been reduced by around 99%. All three species are listed as Critically Endangered on the IUCN Red List of Threatened Species, and face extinction in the wild within the next 10 years. Apart from India, other neighbouring countries like Bangladesh, Nepal and Pakistan have also witnessed similar decline in their vulture populations. The main reason behind their decline has been attributed to the widespread indiscriminate use of the Non-Steroidal Anti-Inflammatory Drug (NSAID) Diclofenac. This has been used specifically among livestock as a common drug to treat pain in domestic animals. Deceased carcass of livestock (with Diclofenac residues), when scavenged by vultures, has been known to cause renal failure in vultures and hence a decline in their populations (Green et al. 2006).

Diclofenac is in extensive veterinary use for treating cattle to relieve them from pain. Although the veterinary use of Diclofenac has been banned in India since 2006, human formulations of Diclofenac continue to be used for treating livestock populations illegally. Diclofenac residues remain present in the carcass even after death and when vultures feed on the carcass, they indirectly consumes Diclofenac, which is harmful for them. Substitutes for Diclofenac are now available in the market, specifically Meloxicam. This drug can treat cattle in the same way, without harming the vulture population. Apart from Diclofenac, a few other NSAIDs like Ketoprofen, and Flunixin have also been documented to pose a threat to vulture populations, albeit to a lesser extent.

Several collaborative projects and initiatives to address the long-term survival of vulture species have been initiated across the South Asia region. More recently, in 2012, IUCN and the Government of India were instrumental in bringing together the governments of Bangladesh, India, Pakistan and Nepal, in agreeing to joint management and policy-level actions for the long-term conservation of South Asian vultures. The four countries also adopted a Regional Declaration on the Conservation of South Asia's Critically Endangered Vulture Species, and formed a Regional Steering Committee (RSC) for South Asian Vulture Conservation, constituting membership from the government and civil society. The Government of India was the Chair of the RSC for the first two years, and the current chair is Nepal. Secretarial and technical support for the functioning of the RSC is provided by IUCN India.

Some of the key recommendations made by the RSC thus far (since 2012) include:

- Need for similar national-level recovery plans, in order to build synergies between countries and maintain consistency in conservation approaches across the region,
- Development of a GEF proposal for a regional vulture recovery programme, providing financial assistance to governments and civil societies to implement the plan,
- Need for a first of its kind TEEB analysis of vultures, in order for policy makers in the four countries to make informed decisions in the identification of Vulture Safe Zones (VSZs), as well as regulatory requirements of vulture-safe drug formulations.

In line with the final recommendation, IUCN India Country Office has undertaken a valuation study

Diclofenac is in extensive use as a veterinary painkiller for cattle. Despite being banned in India since 2006, widespread use of illegal Diclofenac formulations continues and is considered to be the cause of severe decline in South Asian vulture populations

on the ecosystem services that have been provided by vultures. This study is being funded by GIZ under the TEEB for India Initiative (TII). TII is a technical cooperation between the Ministry of Environment, Forests and Climate Change and the Federal Ministry for Economic Cooperation and Development (BMZ), Government of the Federal Republic of Germany, through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

Based on the above, the overall long-term goal of the project was to economically evaluate the ecosystem services provided by vultures and integrate them into policy interventions for vulture conservation in South Asia. To this end, the specific objectives were:

- Estimate the economic value of lost ecosystem services (including human health benefits) once provided by vultures across selected sites in India,
- Estimate the economic cost of banning Diclofenac and replacing it with other substitute NSAIDs,
- With the help of cost-benefit analysis, examine the economic feasibility of conservation breeding (ex-situ) and re- introducing vulture populations by investing in Vulture Safe Zones (VSZ).

The project was awarded in September and formally initiated in October of 2014. The project was provided with a two-month extension until June 30th, 2015.

2. Literature review

Ecosystem services are defined as the flow of goods and services provided by the natural environment that benefit people. The concept of ecosystem services was first used in the 1960s (e.g. King, 1966; Helliwell, 1969) and popularised in the 1990s (Daily, 1997, Costanza et al., 1997). The Millennium Ecosystem Assessment (MEA) provided the most scientific and widely accepted framework for grouping and accounting the services provided by ecosystems. The MEA framework grouped the services into four categories: provisioning, cultural, regulating and supportive services. Supporting services like soil formation, nutrient cycling etc. are considered the primary services that help ensure the flow of the other three services that increase the welfare of humankind (MEA 2003). Other than the MEA approach, there is another use-based approach to ecosystem service categorisation, which is used for an economic valuation of ecosystem services. It assumes the Total Economic Value (TEV) of the ecosystem consists of both use and non-use values, which have subsequently been disaggregated into different value components following Krutilla (1967) and others (Pearce and Turner 1991, de Groot et al. 2002, de Groot 2006, and Balmford et al. 2008).

Considerable debate continues on what constitutes an ecosystem service and how each should be quantified (Boyd 2007, Boyd and Banzhaf 2007, Matero and Saastamoinen 2007, Nijkamp et al. 2008, Bartelmus 2010, Farley and Costanza 2010, Kontogianni et al. 2010, Norgaard 2010, Wainger et al. 2010) so that they are taken into account in the decision-making process. The key issues that are being debated include how to value non-market services, how to avoid double counting a process and its end product, and right ways to incorporate ecosystem valuation into policy and land-use decisions (Wenny et al. 2011).

2.1. Ecosystem Services and Birds

Birds are an integral part of the ecosystem, contributing different provisioning, regulating, cultural and supporting ecosystem services that benefit society. Sekercioglu (2006 a&b); Whelan et al. (2008) presented the many services provided by birds and argued that they are an ideal group to examine for ecosystem service valuation. However, little ornithological research has been done in an ecosystem-services context. Notwithstanding this, valuation of watersheds and insect pollination using market-based valuation (Kremen et al. 2007, Brenner et al. 2010) and valuation of cultural and provisioning services i.e. bird watching and hunting (Sekercioglu 2002, LaRouche 2003, Leonard 2008, Carver 2009) have been acknowledged. In addition,

The goal of the project was to economically evaluate the ecosystem services provided by vultures and integrate them into policy interventions for vulture conservation in South Asia

Box 1: Eurasian Jays

Eurasian Jays, a keystone species, supports unique communities of insects, lichens, mosses, fungi, nesting birds and bats. The Jays' natural history of acorn seed-dispersal service in oak forests is especially important for keeping these forests healthy. The technique of replacement cost suggests $4,035 for seeding of acorns and $22,560 if saplings are planted to replace a pair of Eurasian Jays. The overall cost per ha for forest regeneration would be between $2,115 and $9,450.

Farber et al. 2006; Sekercioglu 2006 a&b; Whelan et al. 2008, 2010 have all recognised that supporting and regulating services such as insect/pest control and seed dispersal are difficult to quantify. Weeny et al. (2011) has argued that many of the ecosystem services provided by birds result from their foraging behavior (see Box 1). This behavior has been considered the mobile link that transfers energy both within and among ecosystems, and thus contributes to ecosystem function and resilience (Lundberg and Moberg 2003). Given that birds are important ecologically, the challenge is to quantify their importance in terms benefits/values that are currently meaningful to humans.

2.2. Approaches to Valuation of Ecosystem Services

Valuation is necessary to address the benefits associated with the services provided by the missing market (ecosystem). Two well-differentiated paradigms for valuation are a) the preference-based method and b) the biophysical method. The biophysical method considers only physical cost associated with maintaining a given ecological state, while the preference-based method relies on human behaviour and assumptions from their subjective preferences (Kontogianni et al. 2010).

The value of an ecosystem accounts for two distinct aspects. The first is the aggregated value of the ecosystem service benefits provided in a given state, similar to the concept of Total Economic Value, or TEV. The second aspect relates to the system's capacity to maintain these values in the face of variability and disturbance (TEEB study). TEV is a widely used utilitarian framework for valuation of ecosystem services. This concept was first coined by Weisbrod in 1964 and further refined by Krutilla in 1967. In recent years, this has been widely accepted as a suitable tool for valuations under two broad categories of values: *"use values"* and *"non-use values"*. Use value mainly refers to the value of ecosystem services that are used by humans for production or consumption purposes. Use value can be further disaggregated into direct use values, indirect use values and option values. Direct use values are the ecosystem services directly used for consumptive or non-consumptive purposes. Indirect use values are the ecosystem services used as an intermediate input for the production of final goods and services such as soil, water etc. Option value refers to the fact that even though people are not directly deriving any utility from them, many ecosystem services still hold value for preserving the option of using it in the future either by the individual (option value) or by others. Non-use values are usually defined as bequest value (what you leave to your children) and existence value (the value of knowing that something exists even if you do not use it). Different categories of ecosystem services described in the MEA are valued using the TEV framework by establishing the link between services and the type of values they generate. Following TEEB (2008), the

Table 1: Valuing Ecosystem Services for Birds through the TEV Framework

Group	Service	Direct value	Indirect value	Option value	Indirect value
Provisioning	Food, bedding, insulation, ornaments etc.	Yes	NA	Yes	NA
Regulating	Carcass removal, Disease/pest control	NA	Yes	Yes	NA
Cultural	Bird watching/Birding, photography, Ecotourism, religious customs	Yes	NA	Yes	Yes
Habitat (Supporting)	Seed dispersal, Pollination, nutrient cycle	Other services are utilized to measure the supportive services in TEV framework *			

NA: *Not applicable*

* *Supporting services are the intermediate or primary services that help in providing other services which are directly or indirectly used by people. Hence, including supporting services in TEV will result in double counting.*

ecosystem services provided by birds and the values they generate are shown below in a TEV framework (Table 1). Adding those values generates the total economic values of the bird species.

The study under TII aimed to use this framework to value the ecosystem services provided by the three species of Gyps Vultures, presently critically endangered in Asia. The review of literature that follows on the services provided by vultures is presented as per the stated objectives of the project.

3. Ecosystem Services of Vultures

Traditionally, vultures have been recognized to provide two important services to society, (i) regulating service in the form of carcass removal and (ii) cultural service to some sections of society, namely Zoroastrian-practicing Parsi communities. Thus, the decline in Asia's vultures has resulted in the loss of these critically important ecosystem services, imposed high economic burden on society as well as a loss of culture and sentimental values, which can't be accounted for in terms of numbers. The specific burdens on our society and the environment due to a decline in vultures are described below.

3.1. Loss of Carcass Removal Service and Impact on Human Society

It was estimated that vultures once removed some ten million tonnes of carrion a year from the landscape. With the decrease in vultures, carcasses are left to openly rot, leading to significant waste disposal problems, and a growing range of health concerns to humans. Amongst other impacts, there has been significant increase in the number of feral dogs, a rise in the number of dog attacks on humans (Box 2), and a reported increase in rabies and tuberculosis as livestock-borne diseases (Prakash et al. 2003). Historically, the role of cleaning up carcasses and preventing health hazards to humans as well as to livestock was ably played by vultures in our landscapes. However, the rapid decline in vultures and lack of alternative and efficient ways to deal with carcass disposal has led to a certain imbalance in landscapes. It has been reported that vulture decline has led to an increase in the number of dogs, because of the abundance of food availability in garbage dump yards (Ananth 2012). Markandya et al. (2008) was the first to clearly document all known and attributed services that vultures (Picture 1) have provided to human society and to the environment in general. The paper also provided interesting valuations for some of these services. It has been widely recognized that concurrent with vulture die-off, there has been an increase of 5.5 million feral dogs, which has resulted in over 38.5 million additional dog bites, and more than 47,300 human deaths from rabies (Markandya et al. 2008). The study also estimates that the increased number of rabies victims may have

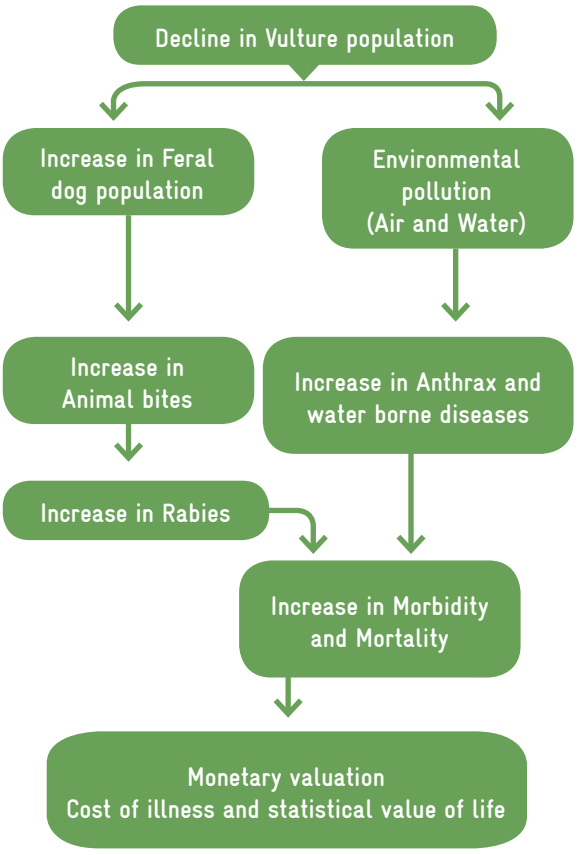
Box 2: Rabies Deaths

Million Death Study conducted by WHO in the selected states of India reflects that most rabies deaths occurred in males (62%), in rural areas (91%), and in children below the age of 15 years (50%). One third of the national rabies deaths were found in Uttar Pradesh (4,300) and nearly three quarters (8,900) were in 7 central and south-eastern states.

Source: *Suraweera (2012)*

Figure 1: Repercussions of Vulture Decline

(Markandaya et al. 2008)



cost the Indian economy over US $34 billion. To support long-term recovery and conservation plans for Gyps vultures in the region, it is critical that these estimates and relationships are further validated to fully understand the true value of the services that we have lost with a decline in vulture populations.

More recently, Thom van Dooren (2014) has documented the relationship between vultures and Indian society and argues that the Indian sub-continent is probably the best landscape for the continued survival of vultures that are currently facing extinction (see Box 3).

In addition to the actual loss of human lives, WHO reports indicate significant post exposure treatment of rabies costs to humans, (₹252/ US $6; treatment in government hospitals for medicines/vaccines and doctor visits; treatment in private hospitals are likely to be double or more, see Box 4 for more details) and an associated loss of 2.2 man days (Sudarshan et al 2006). In addition, the estimated wage income loss of the sick person is ₹220. Therefore, the total cost to a person due to a dog bite is ₹472 (medical expenditure + wage income loss). This report also places the total cost of post exposure treatment of humans in India to be around US $25 million to the government. It has also been estimated that the annual expenditure on treating rabies in South Asia is over US $563 million (Baxter 2012). These estimates clearly indicate that providing affordable treatment of rabies in India is still a challenge and given the fact that over 62% of the rabies-related deaths occur in rural India, it is matter of life and death for lower income groups in rural India.

Apart from Rabies, vultures have also been known to help in reducing the spread of Anthrax spores, Brucellosis and Tuberculosis in livestock as well as in humans (see Box 5). In addition to the spread of rabies, increase in the prevalence of Anthrax (Stanford Medicine New Centre 2005), Bovine Spongiform Encephalopathy (BSE) and Tuberculosis (Adam 2005) among humans and livestock have also been associated

Box 3: Vultures and Carcass Disposal

India was one of the last strongholds of the vulture species. Throughout most of the second half of the twentieth century, during the period of decline in Southeast Asia, life was good for vultures in India. In 1985, Indian vulture populations were still so large that some speculated that the Oriental White-backed vulture "was possibly the most abundant large bird prey in the world" (Pain et al. 2009). In India, there was nothing like the food shortage for vultures that occurred to the east-quite the opposite. While vultures in India certainly benefited from it being one of the most cattle countries in the world, from a vulture's perspective what makes India an ideal place to live is that most of the cows there are not consumed by local people. Hindu reverence for cattle, alongside a more general ethos of ahimsa (non-violence towards living things), has produced a unique and complex environment in which most Indians do not eat beef and many are vegetarian (although Muslims and a growing number of Hindus do eat animals, including sheep, goat and sometimes cows (Robbins 1998).

Cattle are used in India predominantly for ploughing, milking and as general beasts of burden, and their dung is widely used as fuel and fertiliser (Robbins 1998:226). When they die, cows are usually either taken to carcass dumps or left at the edge of the villages, often after being skinned for leather (Singh 2003). By and large however, it is vultures that have been relied upon in India to "take care" of an estimated 5 to 10 million cow, camel and buffalo carcass each year." As many as 100 vultures may feed on a single cow carcass, stripping it clean in 30 minutes. 2000, 3000, 10,000 vultures swarmed the large dumps in the early 1990s, the huge birds lapping at carcasses with their leather tongues, thrusting their narrow heads neck-deep to reach internal organs, tussling over choice gobbets of meat (McGrath,2007). In this context, vultures often lived quite closely with humans. In urban and semi-urban environments, they found abundant food at carcass dumps, as well as tanneries, slaughterhouses, garbage dumps and bone mills (where they could pick the bones clean before they were crushed for use in fertilisers). But it was not just vultures that benefitted from the association. These industries and local communities were provided with free and efficient means of carcass disposal for the millions of cows that they kept but did not eat (as well as the waste products from numerous other kinds of animals).

Source: *Thom van Dooren (2014)*

Box 4: Vaccine Costs

The market price of the rabies vaccine could cost dog bite victims anywhere between ₹1500 - 5000, resulting in a true cost per bite of between ₹1720 – 5220.

Source: *Suraweera (2012)*

Box 5: Correlation of Exposed Carcasses and Disease

It has been suggested that before the spread of Anthrax and outbreak of BSE in Spain, there was a significant reduction in the number of vultures from the sky and a pile of unscavanged carcass were left in captive breeding centres.

Source: *Central Disease Control USA bulletin (2008)*

with the increase in dead and decaying carcasses in dumping grounds. However, the relationship between the decline in vultures and the increased prevalence of these diseases and the related costs incurred in the treatment both by an affected individual and the state needs to be further investigated.

Apart from minimising the spread of harmful and often fatal diseases in humans and livestock, the decline in vultures has also resulted in an increase in expenditure by the state in putting in place appropriate and functional alternatives, like carcass rendering plants. There is also an additional cost on the human efforts required in collecting and delivering the carcasses to these plants.

Box 6: Carcass Processing Costs

In the absence of vultures, processing of carcasses will require large investments from government agencies. It has been estimated that the fixed cost of processing 4-5 carcass per day is ₹15 lakhs, with an annual working capital of ₹4 lakhs. The value addition has been estimated to be around ₹9.5 lakhs per annum due to recovery of costs from by-product, providing a net annual profit of ₹5.6 lakhs. These rendering plants have a payback period of 2.5 years.

Source: *(Ahuja 2011)*

These carcass rendering plants, while playing a crucial role of removing dead and decaying carcasses, also provide economically beneficial by-products, including Hides, Bone meal and Meat meal (livestock), tallow and bones (Ahuja 2011, Box 6 provides more details). Additionally, these rendering plants provide employment opportunities to local people. The investments in these plants are indeed quite high, while their payback period is quite less as compared to the investment required. Though Ahuja (2011) argues the investment in these plants to be economically viable due to lower payback period compared to the investment required, there are plenty of sustainability, management and environmental issues. There is also the question of availability of enough dead animals to process and sell, and the financial requirement of establishing such plants in different parts of the country, as livestock holding is widespread in India. The state-of-the-art rendering plant in NCR Delhi located at Gazipur is non-working since 2009, due to unavailability of takers. Such issues reinforce the need to bring back vultures to society. This is possible by investing in vulture breeding centres first, and then providing conducive atmospheres for survival by eradicating the harmful factors that led to the disappearance of vultures from the country.

In India, the traditional practise has been to move the carcass of livestock (specifically cattle and buffalo) to designated dumping grounds. In these places, specific livelihood options were exercised, including skin and bone collection. Importantly, the job of the bone collectors was made easy by the quick feeding habits of vultures, who were efficient in consuming the soft tissues of the carcass. These days, in the absence of vultures, bone collectors have to put in extra effort in order to clean bones for the fertiliser industry.

3.2. Health Cost to Wildlife

It has been recognised that the decline in vulture populations has led to an increase in population of secondary scavengers (feral dogs, rodents, hyenas etc). Of importance to this study is the possibility of dog-transmitted rabies, posing a threat to the conservation of threatened fauna in Protected Areas. It has been reported that the introduction of canine rabies resulted in the local extinction of African wild dog populations in the Serengeti- Mara ecosystem (Tanzania/Kenya) in 1989. The feral dogs have also been implicated as a source of canine parvovirus (CPV), contributing to gray wolf mortality on Isle Royale, and as a potential source of canine adenovirus (CAV) transmitted to

maned wolves in Bolivia. The most infamous CDV epidemic occurred in the Serengeti in 1994, wiping out a third of all lions (>1,000 individuals) and many hyenas, leopards and bat-eared foxes (Parker et al. 1996). While there is no detailed reporting of such incidence from PAs in India, there has been a sole record of a wild tiger being bitten by a feral dog in 2013 (see box 7).

3.3. Cultural Value of Vultures

Apart from the known economic values of the ecological/environmental services provided by vultures, these birds are also reputed for their intrinsic value to the Zoroastrian- practicing Parsi communities. They believe that air, water, fire and soil are pure elements and need to be preserved, so their dead are laid in the ''Towers of Silence" and disposed of by scavenging vultures (SAVE 2014b). The ancient custom of 'sky burial' is also followed by Tibetan Buddhists for centuries. Such communities are also undergoing economic burdens, over and above the loss of cultural and sentimental values (see Box 8).

3.4. Vultures and the Pharmaceutical Sector

The least expensive of the NSAID drugs — Diclofenac — has been recognised as a key cause for the sudden and rapid decline of vultures in the region. Web search (Medindia.net) on the number of companies manufacturing Diclofenac is quite startling. Over **639** registered manufacturers of Diclofenac in India are listed and they market around **1047** generic formulations of Diclofenac. The alternative drug Meloxicam, that has been promoted as the most suitable and safe alternative to Diclofenac has fewer companies producing the drug. Only **20** companies are involved in producing Meloxicam with over **40** brands of generic formulations of Meloxicam (Tablet, capsule, injection, gel etc.) Before the 2006 ban on the veterinary use of Diclofenac, vials ranging in volume from 5, 10, 15, 25, 30, 50, 100 ml (mainly tablets) (Drugsupdate.com) were easily available. However, since the effective implementation of the ban, the vials are now restricted to 5-25 ml only. The ban and the subsequent awareness campaign on Diclofenac and safer alternatives have had desirable impacts, as Diclofenac use between 2005 and 2009 reduced. More recently, there is data to show that Meloxicam prevalence has increased. However, extensive use of Meloxicam has been reported to be significantly higher only in a few parts of India, like Jammu & Kashmir and Punjab (Naidoo et al. 2010). Unless the ban is 100% successful, any attempt for restoring vulture numbers will completely fail (see Box 9).

Some years back, it was recognised that subsidising Meloxicam is the only way of promoting its use more widely, as the price differential was too high (see Box 10). Though presently the prices are comparable, a detailed analysis is still required to understand the costs that the government has to incur in subsidising Meloxicam either by subsidising the production process or subsidising the inputs.

3.5. Reviving Vulture Populations – The Economics of Creation of Vulture Safe Zones

Since 2000, the South Asian vulture range countries have been focusing on conserving the species in India

Box 7: Illness and Wildlife

A wild tiger was been bitten by a rabid dog in Panna Tiger Reserve situated in Madhya Pradesh. The three year old tiger has been quarantined and is being treated.

Source: *India today (September 17, 2013)*

Box 8: Monetary Effects in Religious Communities

The loss of vultures has also given rise to costs to the Parsi community of ₹1.6 million and a loss of user and non-user benefits.

Source: *Markandaya et al. (2008)*

Box 9: Need for Holistic Implementation

In Israel, attempts have been made to breed Gyps Fulvous and set them free once they reach maturity but this attempt failed completely because of lack of effort in eradicating the reasons for vulture decline in the first place.

Source: *Becker (2009)*

Box 10: Economic Factors Driving Decline

The cost of Meloxicam is ten times more than Diclofenac.

Source: *Markandaya et al. (2008)*

Box 11: Vulture Restaurants

Currently there are six 'vulture restaurants' in Gadchiroli- Marakbodi, Madetukum, Nimgaon, Yeoli, Navegaon, Krupala and Porla. The forest officials pay ₹250 per Diclofenac free cow or bull.

Source: *Pinjarkar 2014*

through a number of interventions that include banning of Diclofenac, investing in Vulture Conservation Breeding centres (for future release in the wild), providing safe food for vultures in the form of Vulture restaurants (see Box 11) and the creation of Vulture Safe Zones (VSZ). For the long-term recovery and conservation of the Gyps species of vultures, breeding and re-introduction programmes must go hand-in-hand with the creation of trans-boundary Diclofenac-free "VSZ", a network of focal sites for vulture conservation. In order to provide an effective Diclofenac-free area, these VSZs must be within a minumum radius of 100 km and area of 30,000 km^2. The budgetary requirements for the creation of three Vulture conservation breeding centres in India led by CZA (Central Zoo Authority) was approximately ₹2.16 crores (CZA personal communication).

The ambitious Vulture Safe Zone concept was initiated in Nepal. With supporting funding from national and international sources, the project was able to expand the Vulture Safe Zone concept to cover 22,206 km^2. The key reason behind the success was a complete ban on the use of Diclofenac in the nearby districts of VSZ and educating locals about the benefits associated with Meloxicam (Chaudhary et al. 2011). Most of the local veterinary pharmacies sell Meloxicam and the district was declared 'Diclofenac free'. However, there was an absence of evaluation of efficacy of the advocacy and awareness programme, as no data was available on the analysis of cattle or vulture carcasses to look at Diclofeanc prevalence.

To further strengthen the attempts in conserving vultures, the concept of vulture restaurants has been initiated, where an area will be designated near the village, so that locals can throw carcasses. But before throwing carcass, villagers need to inform the forest department, to ensure that there is no Diclofenac residue in the carcass. However, it is not clear what measures were in place to ensure that the cattle carcasses offered were free of Diclofeanc. There is no data to support if this initiative was successful or a failure in saving vultures.

For better, informed decision-making, it is crucial that these efforts are understood through a valuation process, i,e. the societal benefit from the investment in VSZ, and the amount of investment necessary for such efforts. Questions that need to be addressed before such efforts can be upscaled in their implementing include criteria and basis of defining an area as a VSZ, surety regarding the regular supply of Diclofenac-free food and most importantly, the fact that vultures have large ranges and that these areas indeed continue to be Diclofenac-free. We take up the economic issues first by discussing the valuation and cost benefit analysis of VSZs.

4. Valuation of services provided by vultures

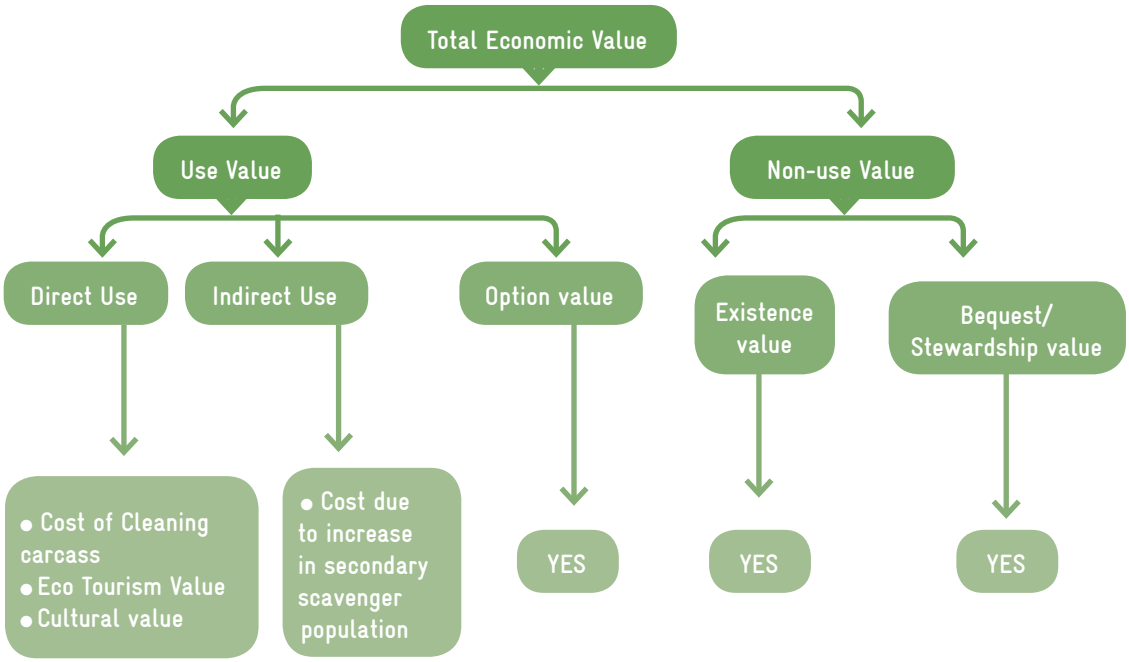
4.1. Methodological Review

The concepts of ecosystem services and 'natural capital' have recently been developed to make explicit this connection between human welfare and ecological sustainability for policy, development and conservation initiatives (Daily 1997, MA 2005). Ecosystem service values of vultures have been derived by many studies with the help of various valuation methods. Like the use based valuation method, there is a cost based valuation approach, which is based on estimating the costs that would be incurred if the benefits derived from ecosystem services had to be recreated through artificial mechanisms.

It mainly has four common techniques i.e. Avoided Cost Method, Replacement/Substitute Cost Method, Mitigation Cost Method and Restoration Cost Method. These estimates do not provide any willingness to pay for the services, but the main assumption behind this technique is to value the cost incurred by people due to a lost ecosystem service(s). However, most studies have used Preference based methods to address valuation of ecosystem services provided by vultures or fauna (refer to Annex 1 for details).

The present study values the carcass disposal service of vultures with the help of the replacement cost method. The replacement cost estimates how much it would cost to replace the lost biodiversity benefit with a substitute. We use the replacement cost of cleaning the carcasses by estimating the amount required in establishing such a plant, and how long these plants will work (depreciation value of plant) etc. This estimation provides the net cost of disposing a carcass in the

Figure 2. Valuing Health Damages from Reduced Vulture Population in India



absence of vultures (refer to Annex 2 for a review of Replacement cost method). The study proposes to use the framework provided in Figure 2.

Vultures provide the most important provisioning services to human society through carcass clearing, which also provides some auxiliary services to bone and skin collectors etc. Primarily, this important service of vultures to both urban and rural scenarios will be evaluated in the present project. Vultures also provide regulatory services to the environment by consuming the carcasses and reducing spread of diseases and increase in secondary scavengers. Vultures have a direct use value by reducing the cost of carcass disposal, and they may have some option value and non-use value.

Cultural services provided by vultures include the sentimental value of Parsi communities attached to the 'Tower of Silence'. The proper valuation of non-market environmental commodities, such as the recreation value of wildlife viewing or a site such as a nature reserve, has significant policy implications. However, since habitat services are intermediate, no attempt is made to value these. To sum up the project, when designed, it intended to value four important services of vultures: (i) carcass removal from society, (ii) cultural value to Parsi communities, (iii) tourism value and (iv) benefit to wildlife through control of secondary scavengers.

4.2. Stakeholder Meeting to Discuss the Methodology and Advice the Project:

The stakeholder meeting for the project involving senior valuation experts, national and global vulture biologists, local civil society agencies and members of the TII STAG was held on the 28th of January, 2015. The key focus of this meeting was to discuss the proposed methodology and sources of information/ data presented by the project team. Key messages for the project from this meeting were:

- The existing studies on vultures do not provide clear evidence of the ecosystem functions of vultures as controllers of epidemics, spread of diseases and/or population rise of secondary scavengers such as dogs, cats, jackals, etc.,
- The relationship between vulture decline and increase in dog population would be a challenge to prove due to paucity of data,
- Vulture breeding sites need to be recognised as an important part of any vulture recovery plan,
- The impact of increase in use of incinerators by municipalities for carcass disposal also needs to be studied. In addition, what would be the cost of carcass disposal and the optimum number of vultures required for carcass disposal? The economic cost associated with providing breeding sites for vultures and disposal of carcasses (sites for feeding

In the absence of vutures, carcass utilisation plants will be the replacement of natural carcass disposal. The cost of such plants thus represents an indication of the benefit vultures previously provided

the carcasses to vultures) also needs to be taken into account

- Cultural values to Parsi communities may not be investigated or surveyed through questionnaires due to the sensitivity of the community towards vultures and 'The Tower of Silence'.

Based on the above, the focus of the study was centred on the carcass disposal service and the economic viability of vulture breeding sites for their eventual release in Vulture Safe Zones (VSZ). The following valuation techniques were used to address the project objectives.

4.3. Valuation Methods used

a) Economic value of carcass disposal service

The replacement cost methodology is used to estimate the economic value of carcass disposal service in the absence of vultures. In absence of vultures, their carcass disposal service needs to be substituted by the next best alternative. Different types of meat processing plants, like rendering plants, exist in India that process the meat of old and live animals for export or domestic use. Services rendered by such plants are not comparable to the scavenging services of vultures, as the plants deal with live animals. State governments have floated centrally sponsored schemes to establish utility plants for utilisation of fallen (dead) animals and centralised banks like NABARD (National Bank for Rural Development) have floated cost estimates of these plants for interested investors who can get a loan from the bank to set up such plants. It is important to note that these schemes were announced during a time when vulture populations in the country had faced a drastic decline. We assume such plants to provide the substitutable services to vultures as they are set up to take care of rotting carcass that would have previously been taken care of by the vultures. Under both the regimes, utility plants without vultures and vultures without utility plants, benefits like bones, skin of the animals, etc. are available for other uses, with the exception of meat and tallow that are consumed by the vultures. This extra benefit from utility plants can be ignored as vultures provide the scavenging service in the most environment friendly manner and the primary purpose of investment in utility plants is not the provision of producing meat meal, but rather taking care of fallen animals in the absence of vultures. Thus, carcass utilisation plants are the replacement of the carcass disposal service of vultures. Society needs to invest in carcass utilisation plants to get rid of the carcass generated, so the cost will act as an indication of the benefit that vultures provided previously.

For arriving at the economic value for carcass removal service, we have used two models of utilisation plants that are supported by the Government of India. The two models used are; a) Low capacity plant that has the ability to process 5-6 carcasses per day and b) medium capacity plant that can process 20-25 carcasses per day. The specifications of these plants are given by NABARD[1]. Plants can run only for 10 years and after that it needs to be revamped. The establishment cost of these plants were reported to be ₹1.5 and ₹2.8 crores respectively and the annual running costs to be ₹0.07 and ₹0.15 crores respectively in the year 2011-12. First, we transform these costs to 2014-15 prices using the annual average rate of inflation in this period (2011-12 to 2014-15)[2], then we annualise these costs and take their discounted values as the value of carcass rending service of vultures.

The present value is calculated by using this formula:

$$PV = \sum_{t=1}^{n} \frac{E}{(1+r)^t}$$

where PV is present value

t = t^{th} period

n is number of years the plant can operate

E is expenditure for t^{th} year,

and r = discount rate

This formula can also be used to measure the present value of future stream of benefits by replacing

[1] *Please see for details: http://ahd.maharashtra.gov.in/pdf/schemes/centrally_sponsered/Utilization%20of%20Fallen%20Animals.pdf, accessed on 2nd August 2015.*

[2] *We estimate at 2014-15 prices as the costs of establishing VSZ were available at current prices only.*

the expenditure by return. If any return is available permanently, like some ecosystem services if the ecosystem is not destroyed, then the formula changes to the following:

$$PV = \frac{R}{i}$$

where R is the annual return which will be available for all years to come and i is the discount rate. For such cases, it is always advisable to use low rates of discount, between 2 and 3%.

b) Prevailing cost of Diclofenac and Meloxicam in KP corridor

The Kanha-Pench corridor was surveyed with the aim of investigating the usage of Non-Steroidal Anti-Inflammatory Drugs (NSAID) including Diclofenac and Meloxicam, in treatment of livestock. During the survey, the use of the safer alternative drug Meloxicam by veterinarians, para-vets, and livestock owners was also documented. In addition, dispensaries in the corridor were visited to document the availability of these NSAIDs and their market value. Discussions were also held with livestock owners and skin collectors on prevalent ways of disposing carcasses in the KP landscape. This survey was carried out by a field team from FES (Foundation for Ecological Security), that has been working in the landscape with the local communities for over 8 years now. The questionnaire surveys are provided in Annex 4&5. Fieldwork was mainly focused on the weak link villages in the corridor (FES field survey report).

c) Economic value for the design & functioning of Vulture Safe Zone (VSZ)

The successful design and functioning of VSZ is dependent on a) the creation of a landscape that is free of Diclofenac, b) the availability of suitable habitats for the continued survival of vultures and c) the success of ongoing conservation breeding programmes that will provide for captive bred vultures to be released in the wild.

The net present value of the cost needed to create a VSZ will be calculated by estimating the cost for establishing a conservation breeding centre for vultures (costs have been arrived at in consulation with biologists, by using the highly successful Pinjore centre run by the Bombay Natural History Society). In addition, the annual maintenance cost of the conservation breeding centre and research, monitoring and

awareness programs before and during the process of reintroduction of vultures has also been factored. To examine the economic feasibility of having VSZs, we use the formula mentioned above to measure the PV of the costs incurred to create a VSZ. Then the present value of cost needed to breed vultures and their release in a VSZ is compared with the present value of benefit from vultures in terms of carcass disposal, which is same as avoiding installation of utility plants.

Based on the experiences of vulture biologists at BNHS in running three successful conservation breeding centres (Pinjore, Rajabhatkhawa and Rani), we have used the costs from the Pinjore centre for conservation, which breeds 100 pairs each of three species of Gyps vultures for a period of 20 years. Six different scenarios have been calculated based on fixed cost, annual maintenance and other related cost, with different discount rates. While costs are spent in the present, benefits from vultures are received in future years. Hence, the discount rates are of great importance in this sort of analysis. Next, the net present value of benefits from 600 vultures bred from the conservation breeding centre is measured. The vultures usually have an average life span of 50 years, of which they spend 10 years in captive and then provide the societal benefit of carcass removal from the 11th year onwards. However, with successful breeding, reintroduction in the wild (VSZ) and recovery, the population of the introduced three hundred pairs will naturally grow and it is argued that the carcass disposal service from these vultures will become available permanently to society (at least in this landscape).

Thus, society gets the benefits from a vulture forever. Next, to measure the total scavenging value of all 600 vultures bred in conservation breeding centres and released in the VSZ, we use some of the ecological parameters from vulture specialists of Pinjore. We assume every vulture consumes 4 to 6 kg of meat per week and the total consumption of meat by all 600 vultures will be equivalent to the service provided by a medium carcass utility plant.[3] The medium utility plant processes 1,64,400 kg of meat in a year, whereas the amount consumed by 600 vultures in a year is between 1,15,200 kg and 1,72,800 kg (see Table 3). The present value of the utility plant, as per the replacement cost method, then becomes the discounted economic benefit of the VSZ to society for providing the ecosystem

[3] However, the service from 600 vultures could be equivalent to a small utility plant if the breeding center is located in wild where at least 40 to 50% of food required to feed the vultures can be met freely.

Figure 1: Map of Kanha-Pench Corrodor

service of carcass removal through vultures.

5. Study Area

The total length of Kanha-Pench corridor from the boundary of Kanha National Park to the boundary of Pench National Park is about 160 km, with an outer boundary of 806.72 km (Fig 1). In total, 442 villages have been identified by the Madhya Pradesh forest department in the three districts of Seoni, Balaghat and Mandla. All these villages depend on the forests for their resources. With a population of over 3.67 lakh people and a cattle population of 2.87 lakhs (2001 census), the biotic pressure on the neighbouring Protected Area (PA) is very significant. Of the 248 villages inside the corridor and 194 villages bordering the corridor, the Madhya Pradesh government has identified 43 weak link villages across the corridor as being critical for the overall functionality of the corridor. The surveys undertaken during the study focused on these weak link villages.

The Kanha-Pench Corridor has received much attention in the recent past, as it provides the vital connectivity between two important PAs in Central India and is critical for the long-term survival of the Tiger as well as its prey base. Acknowledging the need for a more participatory approach to conservation, the FD and civil society have been implementing a range of eco-development initiatives and joint forest management activities in the landscape. The Madhya Pradesh Forest Department, to its credit, has developed a management plan with financial allocations for this corridor in an effort to maintain the habitat characteristics and strengthen the corridor. The FD is also involved in regular consultations with a number of civil society organisations who are implementing various activities aiding conservation and have been successful in building synergies.

6. Results & Discussions

Table 2 provides a summary of results from the current study using field surveys, discussions with park managers, and published information.

6.1 Cost Benefit Analysis of a Medium Carcass Utilization Plant and VSZ (Specifically Ex-Situ Conservation Costs)

In an effort to elucidate the economic value of carcass disposal and examine the economic feasibility of captive breeding and re-introduction of Gyps vulture populations in proposed VSZs, we performed a cost benefit analysis. We do this analysis for two settings,

i.e. rural and urban, and compare the benefit cost ratio under three discount rates, 2%, 3%, 4% and 5%. The costs and specifications for setting up the medium utility plant for fallen animals are taken from the Government of Maharashtra notification prepared by NABARD. These cost estimates were provided for 2011-12 for a rural setting and we transform the aggregate costs to 2014-15 prices using the average inflation rate in India from 2011-12 to 2014-15 (8%). The capital cost for setting up these plants was given as ₹2.8 crores, which amounts to ₹4.49 crores for the year 2014-15. The annual running costs given for rural areas are re-specified for an urban setting by using comparable prices as prevalent in an urban area.

Table 3 below describes these costs. We add the annualised capital costs to annual running expenditures to find out the yearly cost requirement to run the medium utility plant in both urban and rural areas. Those amounts are taken as the annual value of the carcass rendering ecosystem services from the 600 vultures bred and released in a VSZ. These values are measured to be nearly ₹70,24,887 for a rural setting and ₹83,46,097 for an urban setting per year, which means the annual scavenging value of a single vulture is ₹11,708 in a rural area and ₹13,910 in an urban area. Under the assumption that the population of these 600 vultures will remain healthy in a *Diclofenac* free environment around the vulture safe zone, this carcass removing service will be available permanently. Thus, the present value of this ecosystem service or the value of the lifetime services of the vultures at present is calculated. Table 4 shows these values at different discount rates. We find that the lifetime present value of a vulture, just for rendering carcass disposal service, varies from ₹2,77,333 at a 5% discount rate to ₹6,95,555 at a 2% discount rate for urban areas and from ₹1,84,167 at a 5% discount rate to ₹5,85,333 at a 2% discount rate for rural areas. As mentioned before, biodiversity projects delivering long-term benefits should be discounted at a very low discount rate and thus, it is appropriate to value a vulture at ₹5,85,333 in rural areas and at ₹6,95,555 in urban areas.

The present value of the amount invested in VSZs (including captive breeding) is calculated next for both an urban and a rural setting simply using a lower annual expenditure to run the VSZ in rural area, i.e. if it costs ₹1.5 crores annually to run a VSZ in urban areas, then it will cost ₹1 crore in rural areas. The initial investment is assumed to be the same in both areas, i.e. ₹3.51 crores as obtained from the Pinjore VSZ. As it requires 20 years to run these VSZs to release all vultures safely, the present values of these costs spent over 20 years are measured for the year 2014-15. Table 4 also describes these values and the benefit cost ratios to judge the economic feasibility of investing in a vulture safe zone.

Even though the benefits are measured from a single ecosystem service, the benefit cost ratios overwhelmingly support the investment in VSZs, as the value of the benefit cost ratio is more than 0.75 in seven of the eight scenarios. This proves that investing in the design and re-introduction of vultures and maintenance of VSZ has greater benefits than investing in a utility plant, which can process the same volume of carcass as that of 600 pairs of vultures of the VSZ. This is happening even at higher discount rates like 4 to 5%, which are less used for biodiversity enhancing projects. If lower discount rates are used, then benefit cost ratios indicate that just the carcass removal service will more than compensate for investing in VSZs. As already documented, vultures also provide other cultural and regulating services, which for the purpose of this study, have not been monetised.

6.2. Diclofenac and Meloxicam

From the field surveys that were carried out by FES with oversight from the project team, the following points emerged:

- A total of 21 veterinarians (including 2 para-vets) were identified and interviewed in the KP corridor,
- In general, Diclofenac (human formulations of 30 ml vials) continues to be easily available
- Use of Diclofenac in the Lamta region of KPC was noted. The reason was that it was deemed to be more effective and powerful than Meloxicam by livestock owners in the Lamta region who were into

The benefit cost ratios overwhelmingly support the investment in VSZs, proving that investing in the design and re-introduction of vultures and maintenance of VSZ has greater benefits than investing in a utility plant

Table 2: Summary of Results

Impact	Valuation technique	Data sources	
Objective 1			
Increase in health costs (humans/livestock) Increase in incidence of human rabies from dog bites	Cost of illness	Published literature Primary health centres/hospitals APCRI, 2004, WHO, 2002 NICD Delhi, 2003 Million death study (Premature mortality in the world) (examination of deaths related to rabies in India)	
Direct human mortality from dog bites	Value transfer method with adjustments as suggested by Markandaya et al. 2008 (VSL of a child is 2 times more than a VSL of an adult)	Published literature, Newspaper articles NICD Delhi 2003	
Increase in human disease resulting from increased populations of other scavengers and altered disease dynamics (e.g., rodent population increase, increase in cases of leptospirosis)	Treatment Cost of Illness	Published literature	
Increase in livestock disease and related mortality (anthrax, brucellosis etc)	Market price of Livestock (before & after disease)	Questioner surveys in local veterinary outposts in KPC	
Increase in health costs(wildlife) Increase in wildlife mortality and related disease outbreaks		Published literature Newspaper articles Local field surveys Discussions with local park managers	
Increase in secondary scavenger population	Direct/Indirect estimates based on FD records and value transfer with adjustments	Local field surveys, Interaction with field director of Kanha Tiger reserve, Local veterinarians	
Increase costs to carcass disposal* Cost to local communities/municipalities	Preventive expenditure & Replacement cost	Municipality records, State/national government websites Annual reports of line departments Published literature Local surveys	
Cost to bone collectors	Questionnaire surveys	Survey of bone collectors in KPC	
Cost to skin collectors or to leather industry	Questionnaire survey	Survey of skin collectors in KPC	
Cultural cost to specific communities (Parsi)	Replacement cost & Contingent valuation	Markandaya et al. 2008	
Cost of switching over from *Diclofenac* to *Meloxicam* in VSZ	Cost benefit analysis of Diclofenac and Meloxicam	Health ministry, Local Veterinary department, Local field surveys of pharmacies in KPC	
Increase policing against use of *Diclofenac*		Local Veterinary department Local field surveys of pharmacies in KPC Surveys of livestock holders	

** please see the sections below for more details*

	Key results
	• Main source of treatment are Government hospitals • Each dog bite involved an average of 4.4 treatment visits and cost ₹252 (vaccines and other medicines) and resulted in a loss of 2.2 days of work (this cost will change significantly when the treatment is in private hospitals)
	• From 1985, India continues to report every year 25,000 to 30,000 human rabies deaths.
	• Number Leptospirosis cases reported in Kerala has reduced from 2044 in 1999 to 1250 in 2009, but number of deaths has increased from 82 to 106 during the same period. • Number of leptospirosis cases reported in Maharashtra has increased significantly from 197 in 1998 to 2355 in 2005 and the number of deaths has also increased from 7 in 1995 to 167 in 2005
	• Amongst the six prevailing diseases in livestock in KPC, 36 livestock owners reported haemorrhagic septicaemia as one of the major diseases, followed by foot and mouth disease (n=32), black quarter (32), mendri (14), eczema (11) and brucellosis (3). • No major recent disease outbreak in KP corridor.
	• Overall, livestock population has reduced over a period in KPC. • 47% of the dogs near Kanha Tiger Reserve have Canine Distemper. • Incidence of a Tiger bitten by dog in Kanha National Park
	• Population of secondary scavengers such as dogs, jackals, hyenas and wolves has increased and are beginning to be management problems in the Tiger Reserve. • Increase in number of cases of spotted dear being killed by dogs in the buffer areas (1-2 per week)
	• Present value of a medium capacity carcass utility plant varies from ₹6.7 crore to ₹7.9 crore (with a 3% discount rate) depending on the location, i.e. whether it will be constructed in a rural or semi-urban area. These plants will run only for 10 years. • In South India, it has been documented that the locals spend ₹1500 to move dead carcasses to a utility plant. The costs of carcass utility plants are over and above such costs to society.
	• 1 Kg bone is sold at ₹6 -7 in the local market. • Time taken to clean carcass has increased due to extra time taken by secondary scavengers in cleaning carcasses
	• Livestock holding has reduced in this area. • 5-7 years back, they managed to collect 2-3 carcass in a week, which has reduced to 1 carcass per month in this region. • Most of the people are now engaged in jobs and working as casual labourers. • 10 years back, they were able to get ₹100-250 for a large animal hide and 30-40 for small animal hide. • Currently, they are able to get ₹300-750 for large animal skin (depending on the quality) while for small animals like goats, they manage to get ₹60-70 for the skin
	• The Parsi community has invested ₹16,00,000 for the service of solar concentrator.
	• Veterinary Diclofenac is not available in the market. • Everyday, a 30ml vial of Diclofenac (for human use) is being sold, which costs ₹46 • A 30ml vial of Meloxicam costs around ₹50. An average of 1 vial is sold every 3 months. • Due to the marginal difference in the cost of both NSAIDs, there is no need of providing subsidies. • The Indian formulation of Meloxicam is not as efficient as Diclofenac. The European formulation of Meloxicam (Metacam®) is equally effective but the price of Metacam® is very high. A 10ml vial of Metacam® (5mg/ml) costs around $144.7 (vetdepot.com).
	• 96% of the surveyed population is unaware of the usage of Diclofenac in treating cattle. Only 4% of para-vets admit to using Diclofenac to treat cattle. • People using Diclofenac were confined to the region Lamta. This region is mainly involved in Dairy business, so due to efficacy of Diclofenac, it is being used.

Table 3: Annual Running expenditure of a Medium Utility plant based on specification given by Government of Maharashtra[$]

Capacity norms	Particulars	Requirements	Total calculation per year	
Capacity of unit	No. of carcasses per day	20	5480 animals producing on average 3,28,800 kg of bones, 54,800 kg of skin and 1,37,000 to 1, 64,400 kg of meat {Meat consumed by 600 vultures in a year's time is in between 1,15,200 kg to 1,72,800 kg}	
	Average weight of carcass (kg)	100 kg (bones 50-60 kg, skin 10- 15 kg, meat 25-30 kg)		
	Operational days per year (365 days *0.75 (to exclude normal holidays)	274 days		
Expenditure parameters		Rates given by NABARD for rural areas in year 2011-12	Revised rates used by researchers for semi-urban areas for year 2014-15	Total cost for semi-urban areas
One vehicle to carry dead animals from different places	Vehicle expenses per month	Rs12000	₹20000	₹2,40,000
Firewood need	Total firewood requirement per year	182.5 MTs	182.5 MTs	₹8,21,250
	Cost of firewood	Rs4000 per MT	₹4500 per MT	
	Cost of consumable salt, chemicals and cleaning agents	Rs20 per carcass	₹30 per carcass	₹1,64,400
	Electricity charges	₹15000 per month	₹18,000 per month	₹2,16,000
	Generator expenses	₹4000 per month	₹5,000 per month	₹60,000
	Misc. expenses	₹6,000 per month	₹6,000 per month	₹72,000
Manpower requirement				
	Manager - No. 1	@₹6,000 per month	@₹50,000 per month	₹6,00,000
	Operator / Flayer - No. 2	@₹4,000 per month	@₹30,000 per month	₹7,20,000
	Driver - No. 2	@₹3,000 per month	@₹20,000 per month	₹4,80,000
	Labourers - No. 4	@₹2,500 per month	@₹10,000 per month	₹4,80,000
Total running expenditure per year		₹15,78,000 as estimated by NABARD[$] for rural area for year 2011-12 calculates to ₹25,32,040 for year 2014-15	Total annual expenditure for urban and semi-urban areas is ₹38,53,250 for year 2014-15	

[$] *For details please see: http://ahd.maharashtra.gov.in/pdf/schemes/centrally_sponsered/Utilization%20of%20Fallen%20An imals.pdf , page 81 and 82 (accessed on 2nd August, 2015)*

Table 4: Cost benefit analysis of captive conservation breeding programmes and release in Vulture Safe Zone (all figures are in ₹ Crores)

Discount rate used	Present value of carcass disposal service (benefit from vultures)	Present value of setting and running VSZ (cost to breed vultures)	Benefit / Cost ratio
Urban setting			
2%	41.73	31.66	1.32
3%	27.82	29.28	0.95
4%	20.86	27.19	0.78
5%	16.64	25.35	0.66
Rural setting			
2%	35.15	23.32	1.51
3%	23.42	21.61	1.08
4%	17.56	20.12	0.87
5%	14.05	18.80	0.75

dairy farming,

- Throughout the KPC, there was little or no awareness of the ban on Diclofenac and its impact on vulture survival
- Of the six prevailing diseases in livestock, 36 livestock owners reported haemorrhagic septicaemia as one of the major diseases, followed by foot and mouth disease (n=32), black quarter (n=32), mendri (n=14), eczema (n=11) and brucellosis (n=03) in the KPC
- Among all the livestock owners interviewed, none reported hiring labor to dispose the dead animals. They do it by themselves or by helping each other. The general practice to dispose the carcass was to leave them in the open in the dumping grounds, except in the case of smaller ones such as calves, which died due to some lethal diseases. These were buried, as their carcasses posed a risk of infecting the remaining animals.
- Three formulations of Meloxicam were available in the pharmacies and their cost was marginally more than the human formulations of Diclofenac (₹46 for a 30 ml vial of Diclofenac, while Meloxicam was at ₹50)

Based on the above, the usage of Diclofenac for treating livestock continues, albeit on a smaller scale. Subsidising Meloxicam is not a solution, as the difference between the price of Diclofenac and Meloxicam is very marginal. Subsidy will work only when the efficacy of the two medicines are the same, which is not the case here. Diclofenac can provide relief within 15 minutes, while Meloxicam takes 4 hours to get the similar result. Subsidy will work only when European formulations are made available, as the European formulation of Meloxicam is as effective as Diclofenac, but has a fairly high price in the market. As we have noticed in the survey of KPC, around 6% of the surveyed people were using Diclofenac to treat livestock. Further investigation is required to enforce the complete ban on Diclofenac usage.

In summary, the present study suggests that it is beneficial for the government to invest in Vulture Safe Zones, rather than other alternatives like carcass utilisation plants. Vulture safe zones are more economically viable in the long term, since the alternatives have a short life, requiring investment every 10 years. More awareness is required among livestock holders, veterinarians, para-vets etc. for proper implementation of Meloxicam. Regular investigation

The present study suggests that it is beneficial for the government to invest in Vulture Safe Zones, rather than other alternatives like carcass utilisation plants

needs to be carried out to implement the proper ban on Diclofenac, as some para-vets are still using Diclofenac. Additional studies are required to correlate the relation between the decline of vultures and increase in diseases among livestock, rise in dog population and rabies incidences.

7. Policy linkages

The Action Plan for Vulture Conservation in India (Annon 1996) recognised the need for the ban of the widely used Diclofenac among livestock; a key reason for the rapid crash in vulture population. After a series of consultations and discussions, the Indian government has banned the veterinary use of Diclofenac in 2006. This has been followed by a series of awareness programs on the need to use alternative and safer veterinary drugs while treating livestock. While there has been a perceptible change in the veterinary use of Diclofenac (Cuthbert et al 2011), the action plan also emphasised the need for ex-situ conservation. So far, six such centres have been established with funding from the Central Zoo Authority. While this is a very positive development, it is of concern that only the Pinjore Centre, run by BNHS, has been able to raise the resources and has had significant progress in rearing the three species of vultures since 2005. The other centres are facing serious challenges in meeting their objective. This has to be immediately addressed, as the decline in vulture population remains high, when compared with decline rates for most other threatened bird populations. In-situ conservation measures alone cannot supplement such a drastic decline and ex-situ conservation initiatives are also needed.

The impact of the decline in vulture populations in forested areas, specifically in protected areas, has been little understood. Through interviews with local communities living in the KP Corridor and interactions with the Field Director of Kanha Tiger Reserve, the current study has established the following facts:

- There is an increase in the incidence of feral dogs attacking and often killing ungulates (largely Chital) in the buffer areas. At least 2 spotted deer are killed each month in these areas, and the forest department spends valuable resources (man-power and funds) in the safe disposal of these carcasses, including burial.
- There is an increase in the population of secondary scavengers like jackals in the Tiger Reserve. While the relationship between vulture decline and increase in jackal population needs greater analysis, the Tiger Reserve managers are already concerned about the impact of such an increase on the food chain for Tigers in the long-term.

Based on these, the study has the following recommendations for PA managers:

- Need for better baseline and time series data on secondary scavenger population in PAs, especially Tiger Reserves
- Need for a time series data to record the sale of human Diclofenac and the safer alternative NSAID drugs from pharmacies, specifically from the seven VSZs that has been planned in India
- Create a network of para-vets and villagers who promote the use of the safer Melaxicam in areas adjoining PAs, especially in and around areas of the seven proposed VSZs
- Need for better and stronger record maintenance of ungulate deaths due to feral dogs and other secondary/obligate scavengers in and around buffer areas of Protected Areas

7.1. Implications for Stakeholders

It is argued that the increase in vulture populations will have several cascading impacts in PAs and human dominated landscapes. Firstly, there will be a decrease in rotting carcasses, particularly in human dominated landscapes. This will lead to a decrease in feral dog population, associated adverse health impacts, as well as prevent the contamination of freshwater sources. As such, governments will not have to spend large amounts of money on carcass disposal and public health. The number of active working days for people will increase, thereby increasing the economic status of the family. In the PAs, the park managers will have to invest fewer resources in mitigating the negative impacts of decaying

The valuation of vulture carcass disposal, as revealed by replacement cost analysis, justifies ongoing efforts and investment in conservation breeding and the creation and maintenance of VSZs

carcasses. Furthermore, the population of secondary or obligate scavengers will be automatically controlled, which will lead to a better balance in the overall biodiversity.

Based on the above and in light of the study findings, the valuation of one of the services provided by vultures, namely carcass disposal, as revealed by replacement cost analysis, alone justifies the ongoing efforts and investment in conservation breeding, and the creation and maintenance of VSZs.

8. Conclusion

Vultures have been called one of the most threatened families of birds on the planet and for good reasons. Vulture populations continue to be precariously small and will remain vulnerable to stochastic events until their numbers recover in the wild. Their populations will continue to be vulnerable as even under the most favourable conditions, doubling the population will take a minimum of 10 years, largely due to the reproductive biology of vultures. This means that vultures will be slow to recolonise areas where they have now disappeared. There is growing recognition that the slow recovery of vulture populations, as already shown recently by BNHS scientists, will not be close to the high population levels of the early 1990s. It has been argued that this is due to alternative methods of disposal of livestock and the significant increase in meat production and export. Nicknamed 'Pink Revolution', the Indian meat industry is second after only Italy, in exports globally. There is also growing realisation that vulture conservation needs to focused on forested landscapes and their adjoining areas to maintain a healthy vulture population that is sufficient to consume the remains of wild carcasses that are killed annually by predators, diseases and floods, particularly in national parks and other natural and semi-natural areas.

Currently, vultures are scarce or absent here. Therefore, reintroduction into areas where they were earlier present is likely to be an important tool in restoring their distribution. As per the current vision of the National Vulture Action Plan, there has been significant success in the conservation breeding programmes of vultures, particularly in Pinjore. Plans are in place for the release of the first batch of vultures in 2016 in an identified VSZ.

Given that there are plans for the design and establishment of 6 more VSZs in India, there is immediate need for greater focus to strengthen the captive conservation breeding facilities that we have in the country. The success attained in the Pinjore Centre can be replicated in other planned centres as well. The success of such VSZs planned in and around existing PAs will additionally benefit the overall management of these PAs. In the absence of vultures in and around PAs, large populations of feral dogs and other secondary/ obligate scavenger species are on the increase. This has already given rise to other challenges such as increase incidence of dog bites and rabies in human and livestock populations, and disruption of the natural population biology of predators and secondary scavengers in forested areas. Dealing with these problems imposes substantial extra costs to government agencies.

However, it is strongly recommended that the success of VSZs (conservation breeding and eventual release in semi-urban landscapes where the three species of Gyps vultures can continue to survive in the wild and provide the ecosystem service that they have been recognised for) is exclusively based on the fact that the areas are Diclofenac free. Given that there continues to be prevalence of Diclofenac in all Indian landscapes (recent studies by BNHS have shown that this is on the decline, but Diclofenac continues to be available and is the most cost-efficient drug), there is need for sustained awareness and advocacy efforts in removing this threat completely.

9. Next steps

As such, IUCN will leverage the results of this study to:

- Continue to refine the valuation methodology and bring in additional datasets from around the country,
- Develop irrefutable justifications for integrating vulture-recovery related interventions into the existing Kanha-Pench Corridor management plan,
- Integrate the results of this study into national-level interventions (including the Vulture Action Plan, India of 2006, which is currently under revision),
- Relate project outputs to disease surveillance and monitor secondary scavengers in PAs. Discussions will be held with the NTCA, the Forest Department of Madhya Pradesh, and the Health and Animal Husbandry Department of Madhya Pradesh, to better advise policy and advocacy, and the implement management plans for both the Tiger Reserve and the corridor,
- Promote the advocacy of replacing 30-50 ml human-use Diclofenac vials with smaller 3-5 ml vials that are appropriate for human use.

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ANNEX 1

Review of Methods Used in Economic Valuation of Fauna

Name of the study	Authors	Methodology
Diclofenac Approval as a Threat to Spanish Vultures	Tyler. N, Stokkan.K.A, Hogg C, Nellemann C, Vistnes A.I and Jeffery G *(2014) Diclofenac Approval as a Threat to Spanish Vultures.* Conservation Biology, Volume 28, No. 3, 630–632	Investigation and post-mortem of dead vultures
Selecting key areas for conservation at the regional level: the case of the globally 'Near Threatened' *Cinereous Vulture Aegypius monachus* in south-east Portugal	Pedro M. Lourenço, Nuno Curado, Filipa Loureiro, Alfonso Godino and Eduardo Santos (2013). *Selecting key areas for conservation at the regional level: the case of the globally 'Near Threatened' Cinereous Vulture Aegypius monachus in south-east Portugal.* Bird Conservation International Vol 23:168–183.	Identifying key areas for implementing conservation strategies (GIS)
The increase in the population of *Eurasian griffon vulture (Gyps Fulvus)* at Jorbeer, Bikaner: carcass dump as key habitats for winter migration in the griffon vultures	Khatri.P.C(2012) the increase in the population of eurasian griffon vulture *(gyps fulvus)* at jorbeer, bikaner: carcass dump as key habitats for winter migration in the griffon vultures *International Journal of Geology, Earth and Environmental Sciences Vol. 2 (2) May-August, pp.157-162*	Visiting carcass dumping grounds and observing their behaviour
Effects of vultures decline on facultative scavengers and potential implications for mammalian disease transmission	Ogada D.L, Torchin M. E, Kinnaird M. F. and Ezenwa V.O (2012). *Effects of vultures decline on facultative scavengers and potential implications for mammalian disease transmission Conservation Biology,* Volume 00, No. 0, 1–8	Experiment based study.
Economic analysis of feeding stations as means to preserver an endangered species: The case of *Griffon vulture (Gyps Fulvus)* in Israel	Becker N, Choresh Y, Bahat O, Inbar M (2009). *Economic analysis of feeding stations as means to preserver an endangered species: The case of Griffon vulture (Gyps fulvous) in Israel.* Journal for Nature Conservation 17: 199—211	• TCM • CVM • Cost benefit analysis of feeding stations.

	How it was conducted	Results
	Investigation of vultures exposed to diclofenac during their feed.	The impact of this product could seriously jeopardize the last remaining large populations of vultures in the EU because Spain holds 95% of the total vulture population in Europe. Product containing Diclofenac that was approved by Spanish Drug and Health Products Agency should be banned.
	selected all the variables and sub-variables, and defined a number of classes of Different suitability within each sub-variable. for each sub-variable, we created a map where the whole study area was classified According to the classes we had defined. This map was converted into a raster layer where each pixel received the suitability score (on a scale of 0–10) that had been defined for its class. Used Weighted Linear Combination (WLC) to integrate various variables.	The nest and foraging site selection analyses provided very different results. The proportion of grid cells with high suitability for nesting is similar in both SPAs (5.7–6.3 %), but the Vale do Guadiana SPA has a larger proportion of high suitability cells for foraging than the Mourão/Moura/Barrancos SPA (15.2 % vs. 7.3 %).
	Visits were always carried out from morning until dusk in order to determine the importance of nocturnal sites.	Eurasian Griffon vultures were seen feeding on carcass dump at Jorbeer and roosting in tree adjacent to the dump throughout their winter migration. No Griffon vulture was recorded in spring and summer, while higher numbers were observed during wintering season. This increase was related to changes in food resources, in particular livestock availability
	Two methods were used to test whether number of vulture was associated with carcass decomposition rates, abundance of facultative scavengers, and number of contacts. Between facultative scavengers. (Small and large carcasses were placed at different sights to note down the number of scavengers spotted). GLM with an exponential distribution is being used to test that number of vultures was associated with carcass decomposition time	Carcass decomposition time was slower in the absence of vultures. At carcasses without vultures the abundance of spotted and striped hyenas increased significantly Mammals were spending more time at carcasses Mammals were coming into contact with one another more frequently, which could facilitate disease transmission between mammalian scavengers at carcasses.
	TCM and CVM questionnaires were distributed amongst visitors at both Gamla and Hai-Bar Nature Reserves. TCM was conducted in order to estimate the use values of the sites as reflected in the travel costs incurred by the visitors. Respondents were offered three main reasons for visiting each site and their ranking will reflect their willingness to view vultures. The total net economic value per foreign visitor on a wildlife viewing safari was calculated. Used a semi-log functional form in order to estimate visitation frequency from ten regions in which the distance between them and the site is increasing by 30 km per region.	The total WTP for the site is 29.5 USD and 21.75 USD for the average visitor at Gamla and Hai-Bar NRs respectively. Feeding stations are economically viable when bring in at least between 0.23–2.12 vultures annually, depending on the site.

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Name of the study	Authors	Methodology	
Modelling the impact of feeding stations on vulture scavenging service efficiency	C. Deygout, A. Gault, F.Sarrazin, C. Bessa- Gomes (2009). *Modelling the impact of feeding stations on vulture scavenging service efficiency* Ecological Modelling 220 : 1826–1835	Sensitivity analysis and investigation of management practices	
Counting the Cost of Vulture Declines – Economic Appraisal of the Benefits of the *Gyps* Vulture in India	Markandaya. A, Taylor. T, Longo. A, Murty M.N, Murty.S and Dhavala. K.K Counting the cost of vulture decline—An appraisal of the human health and other benefits of vultures in India, Ecological Economics (2008)	• Cost of Illness approach • Replacement cost method • Contingent valuation • Cost estimation of bone collectors and skin collectors	
Vulture restaurants and their role in reducing diclofenac exposure in Asian vultures	Gilbert. M, Watson. R.T, Ahmed. S, Asim. M and Jeff Johnson J.A (2007). *Vulture restaurants and their role in reducing diclofenac exposure in Asian vultures* Bird Conservation International (17): 63– 77.	Experiment based method	
Estimating the economic value of viewing griffon vultures *Gyps fulvus*: a Travel Cost Model study at Gamla Nature Reserve, Israel	Becker. N, Inbar. M, Ofer. B, Choresh.Y, Ben-Noon. G and Yaffe.O (2007). *Estimating the economic value of viewing griffon vultures Gyps fulvous: a Travel Cost Model study at Gamla Nature Reserve, Israel. Oryx,* 39(4), 429–434	• Travel Cost Method(TCM) • Zonal Travel Cost Method (ZTCM) • Individual Travel Cost Method (ITCM)	
Evaluation of the extinction risk and of conservation alternatives for a very small insular population: the bearded vulture *Gypaetus barbatus* in Corsica	Bretagnolle.V, Inchausti.P, Seguin.J.F, Thibault J.C (2004). *Evaluation of the extinction risk and of conservation alternatives for a very small insular population: the bearded vulture Gypaetus barbatus in Corsica* Biological Conservation 120: 19–30	Stochastic demographic models All models were analysed by Monte Carlo simulation using RAMAS/Metapop	
Bone crushing carnivores and their significance to osteodystrophy in griffon vulture chicks	Richardson P. R. K, Mundy, P. J., & Plug,I. (1986), Bone crushing carnivores and their significance to osteodystrophy in griffon vulture chicks. Journal of Zoology, 210: 23–43	The bone-collecting behaviour and related aspects of breeding of two species of griffon vulture were studied at five different nesting colonies in southern Africa	

	How it was conducted	Results
	A multi-agent system (MAS) that explicitly models vulture foraging bouts. Modelled local enhancements so that when an individual found resource then others within a given radius become aware that a resource has been found. Investigation was carried out to know the efficiency of the search process itself by recording the mean search time	The local enhancement distance, influenced both the scavenging and the search efficiency of all strategies, which shows the importance of this aspect of social foraging
	Cost of Illness approach was used to measure the potential cost associated with vulture decline which includes mortality among livestock and owner due to increased dog bites leading to rabies. Replacement cost was used to measure the cultural value of vulture associated with parsi. Contingent valuation was used to measure water quality	Total impact on health associated with vulture decline during the period 1992-2006 was estimated to be around ₹998 Billion to ₹1,095 billion. ₹1.6 million needs to be invested by Parsi community or government to arrange an alternative measure to dispose dead body in the absence of vultures. Between the period 1992-2006 number of dogs has increased significantly between 5.5 million to 9 million
	Daily surveys were conducted along the entire 42.5 km of colony between 27 November 2003 and 30 June 2004. Study was divided under different periods	The restaurant was affected by seasonal variations in foraging behaviour, attracting few vultures and no tagged birds during the post-breeding period\d The relative failure of the restaurant to attract vultures during the post- breeding period suggests that the provision of uncontaminated food was unrelated to the reduction in mean daily mortality at this time
	Conducted to estimate the use value of viewing vultures in their natural habitat. To extract the value of viewing vultures from the total value of the trip Respondents were asked to rank their interest in their visit to Gamla from the variety of attributes the site has. The demand function was determined by increasing the admission price repeatedly by intervals of NIS 10, and the variation successfully predicted the number of visits	There was a significant influence of distance on visits per capita Study showed that with an increase in entrance fees, it prevents visitor from coming. Value of the site is USD 1.12 million (at USD 1=NIS 4.4) compared to the revenue from the entrance fee which is c. USD 239,000 per year and a total operating cost of USD 227,000 per year
	Carrying capacity was evaluated in terms of resource abundance. Models were built on age- structured, post-breeding, stochastic Population framework.	results showed that the bearded vulture in Corsica has a relatively high extinction risk (16.5% during the next 50 years) mostly due to the effects of demographic stochasticity arising from its small, although relatively constant, population size
	One Cape vulture colony and one White-backed vulture colony in or near wildlife reserves, as well as two Cape vulture colonies and one White- backed vulture colony in ranching land. A total of 2825 bones was found in or below the vulture nests. Hyena-produced bone fragments were found only in the colonies in the wild areas—none of the 387 chicks examined here had osteodystrophy. By contrast, in the ranching areas, vultures collected larger and less fragmented bones. Many Cape vulture chicks had osteodystrophy	To deal with rickets, the South African Vulture Study Group began to provide bone- fragments in feeding stations. Rickets came down from 16.9% in 1976 to 3.7% in 1983. It is clear that bone fragments are an essential dietary requirement, providing calcium for correct skeletal growth of griffon vulture chicks

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Name of the study	Authors	Methodology	
		Review of methods used in	
Saving the Philippine Eagle: How Much would It Cost and are Filipinos Willing to Pay for It?	Harder. D.S, Labao.R, and Santos. F.I (2006) *Saving the Philippine Eagle: How Much would It Cost and are Filipinos Willing to Pay for It?* (Resources, Environment and Economics Center for Studies, Inc. (REECS)	Contingent valuation method and used two dichotomous choice contingent valuation models (standard vs. one with respondent's uncertainty) to estimate the economic benefits of protecting critical habitat for nine threatened and endangered fish species in Colorado. Calculated WTP estimates using Parametric and Non-parametric approaches.	
The economic value of ecosystem services provided by insects	Losey. J.E, and Vaughan.M (2006). *The economic value of ecosystem service provided by insects*. Bioscience Vol 56(4): 311-321	Three basic ecosystem services (Dung burial, Pollination, pest control provided by insects were valued. Production function is used to estimate these services For all the three services they calculated an estimated amount of each commodity that depends on each services.	
The economic value of a White Stork nesting colony: a case of 'stork village' in Poland	Czajkowski. M, Giergiczny.M, Kronenberg.J, Tryjanowski.P(2014). *The economic value of a White Stork nesting colony: a case of 'stork village' in Poland* Tourism Mangaement Vol 40: 352-375	Individual Travel cost Method (ITCM) was used to estimate recreational use value	
An Economic Valuation of Pollination Services in Georgia	Barfield. A, Dr. Bergstorm.J, Dr. Ferreira.S (2012). *An Economic Valuation of Pollination Services in Georgia* Southern Agricultural Economics Association nnual Meeting, February 4-7, 2012, Birmingham, Alabama	Bio economic approach- Modified production function (State level)	

	How it was conducted	Results
economic valuation of other species		
	The study areas were Davao Region and Metro Manila and respondents were asked how certain they were of making the payment if the proposed conservation program would be implemented. The data collection strategy adopted the drop-off approach. A total of 1,208 usable questionnaires were obtained from about 1,500 households covered in the survey.	The survey shows that environment concerns, specifically endangered species conservation, have a low priority among Filipino households. 26% of on-site and off-site respondents who received different bid levels were willing to support the proposed conservation program. It was noticed that residents of Metro Manila are willing to pay more as compared to Davao residents.
	Estimated the increase in rate of decomposition due to dung beetles as compared to other species. Here it was assumed that reduction in dung persistence will lead to reduction in lost beef	Service provided by dung beetles leads to a 19% decrease in the amount of time the average pat of dung makes forage unpalatable, which translates into substantial monetary savings. Forage fouling- in the absence of dung beetles, beef losses due to forage fouling would be 244 million kg of beef per year. Nitrogen volatilization-the value of the reduction in nitrogen loss is approximately $58 million. we estimated that 21.6 kg would be lost per animal each year if dung beetles were not functioning. Pollination service by insects- Calculate an estimate of the value of crops produced as a result of pollination by wild native insects. Here they estimated the crop dependency on insect pollination and the relative contribution of honey bees. Pest control- Estimation was carried out to derive the value gained from suppression of insect pests attacking crops plants. Estimation was done to calculate the cost of damage due to insect pests at current level from natural enemies. Estimation result shows that $7.32 billion lost annually to native insect pests is 35% of what would be lost if natural controls were not functioning. So the value for pest control for the native ecosystem is approximately $13.60 billion. So the value of natural control by insects sums up to $4.5 billion annually (33% of $13.60 billion)
	Zywkowo (north-east of Poland) was recognised as the study site which lays in the Masurian Lake District. However, it is not close to any major tourist attraction. In 2011, 2850 tourists visited Zywkowo, of whom 583 agreed to complete the questionnaire, resulting in over 20% response rate.	The mean consumer surplus per visit was estimated to be nearly 200 PLN (60 USD), or 396 PLN (120 USD) when the opportunity cost of travel time was included. The total annual social benefit – annual recreational use value generated by Zywkowo – was therefore calculated to be 570,000–1,160,000 PLN (170,000–345,000 USD).
	Estimates of EVP, CVR and PCV are calculated for the state and for each Georgia county. Estimated EVP was considered for the conservation purpose as it neither addresses insect pollination direct impact on cattle industry nor its impact on seed production for vegetative component of other crops for direct human consumption	For Georgia, estimated total EVP to be nearly $608 million. Estimated PCV indicates that the pollination service contributes around 5.4% of the TFGV for the state. CVR indicates that, on average, Georgia counties can anticipate potential production value loss for the crops studied of just over 22.4 11% in the absence of pollinators. Economic value of pollination services comes to be around $608 million, the crop vulnerability ratio is 21% and pollination contributes to 5% of the total farm gate value

ANNEX 2

Review of Valuation Study Using Replacement Cost Method

Name of the study	Authors	Methodology	How it was conducted	
Valuing Insect Pollination Services with Cost of Replacement	Mike H. Allsopp, Willem J. de Lange, Ruan Veldtman (2008) Valuing Insect Pollination Services with Cost of Replacement. PLoS ONE 3(9): e3128.	Replacement costs for wild and managed insect pollination services	The Western Cape deciduous fruit industry (South Africa) was used as a case study to assess the value of wild and managed pollination services. Value of all insect and managed pollination services was calculated by using production function approach. For replacement cost Method two hypothetical scenarios were taken into consideration. Firstly no insects (managed or wild) remain for pollination. Second scenario assumes that managed pollination is not commercially viable or possible, with only its contribution to be replaced (wild pollination service remains). The use of managed non-honeybee pollinators is not considered feasible in the Western Cape.	
Economic valuation of environmental quality aspects of upland agriculture projects in Korea	Kim, S-H. & Dixon, J. 1986. Economic valuation of environmental quality aspects of upland agriculture projects in Korea. In: Dixon, J. & Hufschmidt, M. (Red.) 1986. *Economic valuation techniques for the environment - A case study workbook*. Baltimore, London: The Johns Hopkins university press.	Replacement cost	In order to maintain the productivity of upland area either by physically replacing the lost soil or by adapting a management technique and it will be compared in order to conduct cost benefit analysis. Replacing the earlier technique used for production by a more cost efficient combination of straw and vertical mulching. And it was found out to be the most cost effective management approach in reducing erosion.	
The economic value of wetlands - wetlands' role in flood protection in western Washington.	Leshcine, T. Wellman, K.Green, T. "The Economic Value of Wetlands: Wetlands' Role in Flood Protection in Western Washington". *Washington State Department of Ecology*.,1997	Substitute/Alternate cost method	It evaluates the wetland flood control system by pricing the cost of providing similar flood control system via a next best alternative (it could be construction of an artificial flood control mechanism). Here it was assumed that city is willing to invest in flood control mechanism to improve the flood protection. Willingness to Pay of the residents was treated as a proxy for the value of existing flood protection	

	Results
	The contribution of managed honeybee pollination is found to be between US$28.0–122.8 million. The contribution of wild pollinators is found to be between US$49.1–310.9 million. Higher the relative level of efficiency, the smaller the associated income loss and consequently the lower the value of insect pollination services. The replacement value of insect and managed honeybee pollination was estimated using pollen dusting (standard method) and three hand pollination methods It would not be cost-effective for farmers to produce their own pollen for cross pollination if compared to commercial pollen available at US$175.7 per hectare for hand pollination and US$234.1 per hectare for pollen dusting
	Despite of using the most cost effective techniques the adoption rate seems to be very low in this area and it can be due to various reasons. Willingness to Pay for new soil management technique does not seem to exist despite the fact that it would be economically viable and rational to use straw and vertical mulching as preventive measure. Farmers have not got the incentives to adopt soil conservation technique because they do not own the land.
	Excavation, embankment fill, control structure and landscaping costs, plus mark-up, total $195,000 for this project. The total estimated construction costs of all eight projects amounts to $1,516,137. By their presence in the watershed, the combined wetlands are estimated to reduce flood water flow from 536 cfs to 290 cfs, a reduction of 46%. The North Scriber Creek wetland receives a considerably lower value per acre when considered in isolation ($11,754 per acre vs. $35, 612 per acre) because additional flood control via detention facilities can be achieved at this site much more efficiently, or at a lower cost per cfs reduced, than at other wetlands in the system.

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Name of the study	Authors	Methodology	How it was conducted	
Benefits from restoring wetlands for nitrogen abatement: a case study of Gotland	Gren, I-M. 1995. The value of investing in wetlands for nitrogen abatement. Beijer reprint series no. 47. Reprinted from: *European Review of Agricultural Economics*, 22, 157-172.	Replacement cost methods-Life support function (nitrogen abatement, water buffering, supply of energy and provision of habitats)	The buffering capacity of ground water was evaluated at the cost for a water plant to supply the same amount of drinking water	
Estimation of on-site cost of soil erosion: A comparison of replacement and productivity change methods.	Gunatilake, H.M. & Vieth G.R. 2000. Estimation of on-site cost of soil erosion: A comparison of replacement and productivity change methods. *Journal of soil and water conservation*, 55, 197-204.	Replacement cost - The cost of material used and cost of labour (wages)	Replacement cost was used to compare the cost of three different conservation measures that reduces the soil erosion. First measure has compensated the loss of soil by replacing it with soil from fallow land Second alternative included the replacement of technique (ploughing) to reduce the loss of soil. Two different techniques were available but we are supposed to consider the least cost technique. Third alternative was to estimate the WTP for the services if it is no longer provided by ecosystem. But this alternative was dropped out	

	Results
	Excluding the value for nitrogen abatement, the total economic value of the life support function was estimated to range between SEK 9600- 25000/ha/year. This value was mainly estimated for a matured wetland but it was assumed that the corresponding value for restoring wetland would be half of the lowest value (4800/ha/year).
	First technique was feasible to adapt as it was less expensive and replacement cost valuation can be attempted. Compliance with the second objective was not achieved and hence the third objective of Willingness to Pay was also not proved.

ANNEX 3

Questionnaire for Livestock Owners

Question. 1) What kind of livestock do you have?
- Cow
- Buffalo
- Ox
- Goat
- Horse

Question. 2) What is your main source of earning?
- Farming
- Dairying
- Casual labour

Question. 3) What kind of livestock disease are prevailing in this town?
- Anthrax
- Brucellosis
- Canine distemper
- Tuberculosis
- BSE

Any other please specify:------

Question. 4) Do you use Diclofenac to treat cattle?
- Yes
- No

If No, then Question 5 is not required to answer
Question. 5) How much Diclofenac is given to the cattle during the treatment period?
- 5ml
- 10ml
- 15ml or above

Question. 6) Do you use Meloxicam?
- Yes
- No

If no, then Question 7 is not required to answer
Question. 7) How much Meloxicam is given to the cattle during the treatment period?
- 5ml
- 10ml
- 15ml or above

Question 8.) Whether Meloxicam is easily available in the nearby pharmacies?
- Yes
- No

Question.9) What are the methods you adopt to dispose of carcass?

a) Provide money to throw it in carcass dumping grounds
- Yes
- No

b) Throw the carcass on your own
- YES
- No

c) Give it to forest officials for the consumption of wild animals
- Yes
- No

Any other method: please specify----------

Question.10) Does your profession involves skin tanning/ bone collecting?
- Yes
- No

Answer question 8, if answer is yes…..

Question 11.) Do you work for any carcass rendering plants?
- Yes
- No

Question 12.) Are you in the business of making chappals or any other good from carcass skin for your livelihood?
- Yes
- No

Any other, please specify:----------

Question 13) How much do you earn on daily basis? Please mention:

Question 14) Does your job gets affected due to reduction in vulture population?
- Yes
- No

ANNEX 4

Questionnaire for Veterinarians

Question 1.) How many cases you handle/day?

- 5 - 10
- 10 – 15
- 15 – 20
- More than 20

Question 2.) Are you aware about the ban on diclofenac for veterinary use?

- Yes
- No

Question 3.) Do you think people are still using diclofenac in treating their cattle?

- Yes
- No

Question 4.) Whether Meloxicam is easily available in the nearby pharmacies?

- Yes
- No

Abstract

Extensive use of the Non-Steroidal Anti-Inflammatory Drug (NSAID) Diclofenac to treat livestock has resulted in a sharp decline in the population of Gyps vultures across South Asia. This is of concern, as vultures are the primary scavengers in the wild and a decline in their population can trigger impacts on the population levels of secondary/ obligate scavengers, cultural value and economic services provided for the ecosystem. In this study, we review one of the economic costs associated with vulture decline: the critical service of cattle carcass disposal that they provide to society. In the absence of vultures, these services have been provided anthropogenically with an associated cost. Benefits that vultures traditionally provided become a cost to society, incurred by the government through the establishment of carcass utilisation plants,. This study has additionally focused on calculating the economic value of creating and maintaining Vulture Safe Zone (VZS), as an estimate of costs associated with ex-situ conservation and re-introduction of vultures into the wild. The study compares the economic value of VSZ with that of man-made mechanisms for carcass disposal services.

Keywords: carcass disposal; Vulture Safe Zone; carcass utilisation plant; vulture conservation breeding centre; Diclofenac; net present value; valuation

India a biodiversity hotspot

India is one of the megadiverse countries in the world. It faces unique circumstances as well as challenges in the conservation of its rich biological heritage. With only 2.4% of the world's geographical area, her 1.2 billion people coexist with over 47,000 species of plants and 91,000 species of animals. Several among them are the keystone and charismatic species. In addition, the country supports up to one-sixth of the world's livestock population. The rapid growth of her vibrant economy, as well as conserving natural capital, are both essential to maintaining ecosystem services that support human well-being and prosperity.

To demonstrate her empathy, love and reverence for all forms of life, India has set aside 4.89% of the geographical space as Protected Areas Network. India believes in "वसुधैव कुटुम्बकम" i.e. "the world is one family".

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