Counting the Cost of Vulture Declines – Economic Appraisal of the Benefits of the Gyps Vulture in India[1]

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Abstract
The decline in vulture populations due to diclofenac poisoning has become an issue of some concern in India. This paper conducts a cost benefit analysis of policy options to mitigate these damages. Vultures compete for food with feral dogs, a major source of rabies and bites. These human health impacts are found to be significant and may outweigh costs of moving to alternative veterinary drugs. A preliminary survey of the Parsi community finds no spiritual values, though further work needs to be done on this issue. Even with a number of key benefits not valued – notably tourism and existence values - the net benefits of policies driven by vulture protection are found to be positive.

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1 The Problem of Extinction of Vultures in India

A rapid population decline of three species of vultures, the long-billed vulture (*Gyps indicus*), slender-billed vulture (*Gyps tenuirostris*), and oriental white-backed vulture, (*Gyps bengalensis*) in India was noticed during the Nineties. These species constitute more than 90 percent of the population decline of vultures in India. The decline was noticed by comparing the data on population changes over northern and central India obtained by a road transect survey of raptor populations during two periods 1991-93 and 2000 (Prakash et al. 2003a). Repeated surveys in 2000 and 2003 show that there has been a decline of 81 percent in *G. bengalensis*, 59 percent in *G. indicus*, and 47 percent in *G. tenuirostris* during this period. The estimated decline during the period 1992-2003 is 99.7 percent for *G. indicus*, and 97.4 percent for *G. tenuirostris* (Prakash et al, Forthcoming). Most recent surveys show that all the three species continue to decline at an average annual rate of 50 percent in India, Pakistan, and Nepal. Figure 1.1 shows an oriental white-backed vulture in flight.

This development has led to concerns as to the reasons for these declines and the socio economic consequences associated with the fall in the number of vultures.

Vultures are significant spiritually, economically and environmentally in terms of their ability to dispose of animal and human remains. The report of the International South Asian Vulture Recovery Workshop (2004) identified the following 7 potential causes of rapid vulture population decline: (i) loss of nesting habitat, (ii) infectious diseases, (iii) use of veterinary drugs, (iv) general environmental contamination, (v) deliberate poisoning of carnivores leading to secondary poisoning of vultures, (vi) low food availability, and (vii) exploitation and persecution.

Recent scientific investigations about the causes of vulture decline identified the use of veterinary drugs, especially Diclofenac Sodium, a non-steroidal anti-inflammatory drug administered to domesticated cattle in the Indian sub-continent, as the overwhelming cause of the decline of vulture populations (Risebrough, 2004; Green et al, 2004; Cunningham et al, 2003; Shultz et al., 2004).

Figure 1-1 ***White Backed Vulture***

Source: RSPB website

In this paper we look at the economic consequences of this decline, and, in particular, at the economic costs and benefits of an attempted reversal of the decline based on measures currently being taken by the Government of India. These measures are discussed below.

The structure of the paper is as follows. Section 2 describes the socio-economic impacts of vulture declines on various endpoints and the techniques used to conduct a valuation of a recovery in numbers. Section 3 discusses the data related to the main impacts of vulture decline and the values to be attached to the estimated impacts. Section 4 describes measures to recover numbers and the costs associated with such measures and Section 5 reports the benefits and costs of a recovery program based on selected measures.

2 The socio-economic impacts of Vulture Decline

2.1 Impacts of vultures decline

Vultures can be regarded as a natural resource, like air and water, which provide society with a number of 'services', most notably disposal of carrion. These services

have an impact on human health, economic activity and on environmental quality. An overview of these impacts is provided below.

2.1.1 Human Health

An increase in uneaten carcasses poses a direct threat to human health because the carrions provide a breeding ground for potentially pathogenic bacteria leading to the possibility of direct or indirect infections and are sources of disease, such as anthrax (Pain et al, 2003). In removing carcasses rapidly and efficiently, vultures cleanse the environment and protect humans, livestock and wildlife from infections and other disease. Figure 2.1 explains the relationship between the decline in vulture population and human health. Figure 2.1 illustrates how a fall in the vulture population could result in an increase in feral dog population (Prakash et al, 2003a), which in turn could increase the incidence of animal bites and rabies among humans. Also the loss of vultures might contribute to environmental pollution (air and water) resulting in the increased incidence of anthrax and water borne diseases among people.

2.1.2 Costs to Industry

Important economic impacts of vulture decline include the impacts on the costs to villagers of disposing of carcasses and to collectors of cattle bones for the fertilizer industry. This latter is an old trade among India's poor; vultures effectively and rapidly clean skeletons of all soft material and facilitate the bone collector's job, whilst feral dogs cannot serve as substitutes to vultures because they only scavenge choice tissues.

2.1.3 Recreation

Other important benefits society might receive from the protection of vultures derive from the pleasure people might receive by viewing them, or by simply knowing that the species continues to live in its natural habitat on a sustainable level. For example, several tour operators offer bird watching tours in India to admire vultures.[2]

2.1.4 Existence Values

The values placed on vultures may include values on the option of viewing or bequest values for future generations. Such values may be those of people inside and outside

[2] Naturetrek (www.naturtrek.co.uk) and Wildlife Conservation & Restoration Tourism (http://www.restorationfarms.com/index.html) are among the tour operators that provide tours in India to watch vultures in their natural habitat and in captive breeding programme centres.

of India. Charity collections, such as those raised by the RSPB in response to vulture declines, may be able to capture some of these values.

2.1.5 Cultural and Religious Values

Finally, vultures are important for their considerable cultural and religious significance that some communities attach to their role of disposing of human bodies: for thousands of years and in different parts of the world, humans have laid out their dead for consumption by vultures (Schüz and König 1983).

2.1.6 Other environmental impacts

Wider environmental impacts may include increases in scavenger populations other than feral dogs and water pollution due to the fouling of watercourses by rotting carcasses.

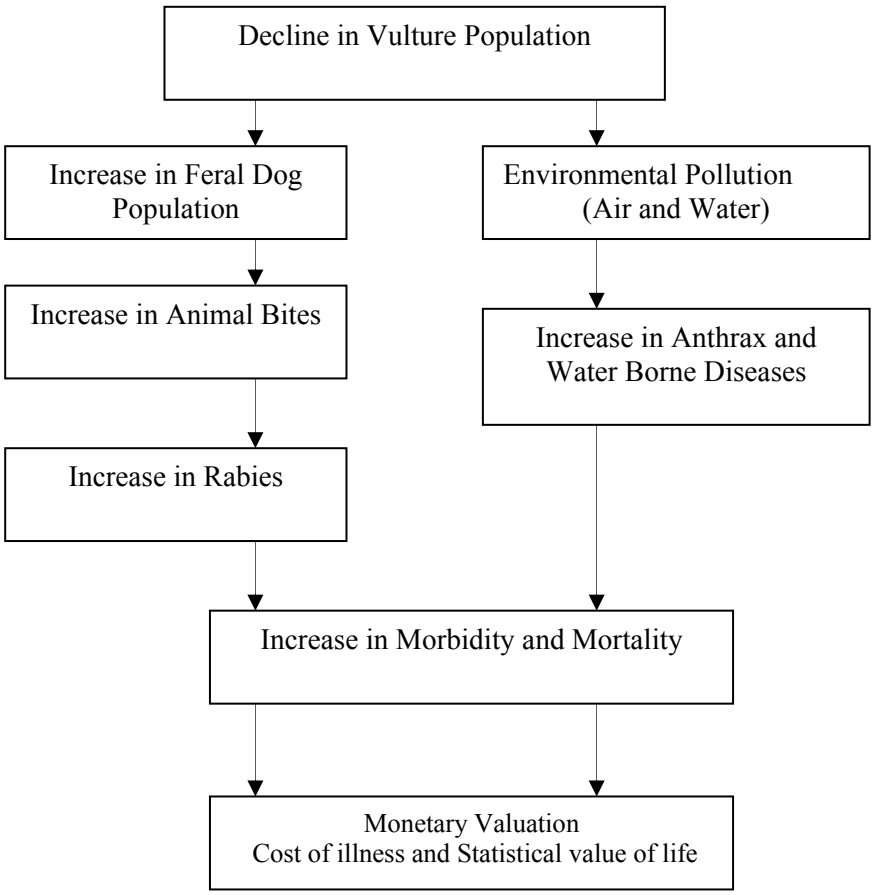
Increases in other scavenger populations may have significant socio-economic impacts. Rats, feral cats and other species may increase in numbers, leading to spread of disease. The spread of rabies is largely attributable to dog populations, but increases in prevalence rates of other diseases may be an issue.

Water pollution is a major issue in India. The values placed on clean water have been assessed by Markandya and Murthy (2000), among others. The linkage between the number of rotting carcasses in water and vulture declines is hard to assess, due to alternative disposal methods. This is an issue that may warrant further investigation.

2.2 Methodology for application of Cost Benefit Analysis to the decline of Vultures

Environmental economists have developed a number of valuation techniques useful to place monetary values on services and goods, such as vultures, that are not directly traded in any market (Markandya et al., 2002). Within a framework for the monetary valuation of health effects, the two strains of human health effects due to the fall in vulture population could be identified in morbidity and mortality effects. *Dose response* function and the *cost of illness* approach could be used to estimate a monetary value of morbidity effects (animal bites).

Figure 2-1 Valuing Health Damages from Reduced Vulture Population India



A dose response function establishes, in this context, a relationship between the number of animal bites and the decline in vulture population. The monetary value of an animal bite to a person could be estimated as the cost of medicine (anti rabies vaccine) and the visit to a doctor and the monetary value of number of work days lost.

The mortality effects could be measured by relating the incidence of rabies (human deaths from rabies) to dog bites and dog population. The monetary value of mortality effects could be estimated by estimating the 'statistical value of life' lost from rabies. The statistical value of life lost is based on what an individual would pay to reduce the risk of death for a certain source. For example, if one million people would each pay two pounds for a measure that would reduce their individual risk of death by one in hundred thousand, the implementation of that measure would save ten lives in the group and the collective payment would be two million pounds. Hence the value of each life saved would be £200,000. This basis for the value of mortality is preferable to one based on the loss of future earnings of the groups, as such an approach places

little or no value on the lives of the very old or very young, whereas the willingness to pay approach places significant value on such groups. For extensive discussion of these issues see Viscusi and Aldi, 2003; Johasson, 2002; Mrozec and Taylor, 2002; Viscusi, 2000.

Table 2.1 below provides a summary of the different impacts that can be associated with a decline in numbers and the methods of valuation associated with those impacts this study attempts to measure. As the table shows, health effects via dog bites and possible benefits from reduced accidents of a decline in vulture numbers have been valued, but the tourism benefits have not, nor have the possible effects of an increase in anthrax and waterborne diseases or the costs to bone collectors of carcasses that have not been cleaned by vultures. The omission of these categories is due to a lack of adequate data. In this respect the values obtained are underestimates of the true benefits.

Table 2.1: Impacts and Costs of Decline in Vulture Numbers

Impact	Method of Valuation	Valuation Attempted
Increased dog bites	Costs if illness and loss of earnings	Yes
Increased dog bites	Costs of premature mortality as value of statistical life	Yes
Water pollution	CVM of water quality	No
Impacts on air accidents	Costs per accident as assessed by air transport authority	No
Religious	Survey of Affected Communities	Yes
Tourism	Survey Methods or by Analysis of Expenditure of Visitors to bird viewing sites	No
Bone collectors	Additional costs of cleaning bones or risk of disease	No
Increased existence value placed on remaining vultures	CVM	No
Increases in other scavenger populations	Costs of illness	No

3 Impacts Data and Associated Values

3.1 Increase in numbers of feral dogs

One of the major impacts of a decline in vultures is believed to be an increase in dog bite and rabies resulting from the growth in the feral dog population that was partly caused by the fall in the number of vultures. This may have partly been offset by the slight decline in livestock populations in India, shown in Tables 3.6 and 3.7. Dog control programmes also may lead to an offset. Table 3.1 provides data about the dog

population in India. It shows that there was a marked increase in the dog population during 1987-1997 coinciding with the period of decline in the vulture population. The dog population increased from 18 million in 1987 to 25.5 million in 1997. The population has increased further since 1997, with it being estimated that there were over 29 million dogs in India in 2003. Another survey, by the National Institute of Communicable Diseases, Delhi (NICD, 2000) has estimated the recent dog population in India at 22 million with 2.28 million animal bites annually. The difference in estimates may be due to sampling methods. Based on the livestock census data we can estimate that in 2006 the dog population, given the annual trend, would be approximately 31.5 million.

It is difficult to say how much of the observed increase in dog numbers is due to the decline in the vulture population. One relationship between the two could be derived in terms of the amount of food each consumed. A vulture consumes an average of 0.5kg/day, while a healthy dog is estimated one fifth of its body weight a week, or about 5kg. This implies that one vulture less would increase food availability for 0.7 dogs.

Table 3.1: Dog Population in India (Million)

Year	Dog Population
1982	18.54
1987	17.95
1992	21.77
1997	25.48
2003	29.02

Source: 17th Indian Livestock Census 2003, Ministry of Agriculture, Department of Animal Husbandry and Dairying, Govt. of India

Another approach is to link the observed decline in vultures to the increase in dog populations. From 1990-93 to 2000 the vulture numbers declined by over 92 percent, or about 27 percent per annum (Prakash et al, 2003). We can estimate the relationship between the dog population and the vulture population by assuming a linear relationship between dogs and vultures:

$$D_t = \alpha + \beta V_t \qquad (1)$$

where D_t is the dog population in time t and V_t is the vulture population in time t.

Hence for t=0, before the decline in vulture population due to meloxicam,

$D_0 = \alpha + \beta V_0$ (2)

and substituting gives

$21.77 = \alpha + \beta(1.16)$ (3)

For t=T, the current period,

$D_T = \alpha + \beta V_T$ (4)

and substituting gives

$29.02 = \alpha + \beta(0.092)$ (5)

Solving for α gives

$\alpha = 29.02 - \beta(0.092)$ (6)

Substituting (6) into (3) gives

$21.77 = 29.02 - \beta(0.092) + \beta(1.16)$ (7)

Solving for β gives

$\beta = (21.77-29.02)/(1.16-0.092) = -6.79$ (8)

Hence, every unit increase in the vulture population leads to a 6.79 decrease in the dog population.

This is a very rough figure because of other factors that have a bearing on dog numbers such as the change in the livestock population and the introduction of a number of dog control initiatives as part of the Government's strategy to reduce rabies. A full consideration of all these factors needs more data and should be undertaken. The full impact of vultures may be greater than that estimated here – as dog control programmes and declines in livestock numbers may have reduced the dog population below what it would have been in the counter factual.

3.1.1 Number of dog bites and cases of rabies

The next stage in the analysis is to estimate the number of bites and the number of cases of rabies, relative to both the feral dog population and to the human population (i.e. number of bites per dog and number of bites per 1000 of population).

As noted above, the National Institute of Communicable Diseases, Delhi (NICD, 2000) estimated the recent dog population in India at 22 million with 2.28 million animal bites annually, or 0.1 bite per dog. Another survey carried out by NICD in 2000 in four urban communities in South India revealed an annual incidence of 2.06 animal bites per 1000 of population (See Table 3.2).

On rabies, a recent study 'Assessing Burden of Rabies in India: Report of the National Multi-Centric Rabies Survey, May 2004' prepared by the Association for Prevention and Control of Rabies in India (APCRI, 2004) in collaboration with the Common Wealth Association, Center for Research in Health and Social Welfare Management provides some estimates of the incidence of rabies in the human population and its economic cost in India. This is a carefully done study using data from a sample of hospitals and a sample of households in India. It collected a decadal data of the annual hospital admissions of human rabies cases during the period 1992-2002 from 22 district hospitals spread throughout the country covering a population of 10.8 million to establish the overall trend of human rabies in India. The household survey was done to search for human rabies incidence in the country.

Table 3.2: Estimated Animal Bite Cases in India during 1999-2000

City	Population Surveyed	Number of animal bite cases in 6 months	6 month incidence per 1000 population
Bangalore	88469	85	0.96
Calicut	79169	20	0.25
Coonoor	43577	70	1.61
Rajmundry	71358	117	1.64
Total	282573	292	1.03

Source: NICD, Delhi (2000), APCRI (2004)

Table 3.3 provides estimates of human rabies cases during the decade 1992-2002 in 22 hospitals of 18 states in India. Overall, rabies cases are falling in this time period. This may be due to rabies immunization for dogs and public health education strategies. Exact data on rabies cases in India are not available – as the surveillance mechanism hardly exists (Chhabra et al, 2004).

Table 3.4 provides the distribution of deaths from rabies by social and economic groups emerging from the household survey. The incidence is very high among the poor, the more vulnerable sections of population accounting for majority of deaths (87.6 percent). Also adult and male sections of population are relatively more affected indicating significant income losses to the households. Table 4.5 provides the information of distribution of deaths from human rabies by state in India. The states of Uttarpradesh, Orissa, Delhi, Bihar, West Bengal and Maharastra, account for most of the deaths.

The household survey targeted a 10 million population exposed to dog bites and rabies. It provides an estimate of 1.7 rabies cases per 100,000 and an estimate of 17,137 rabies cases in a one billion population. If we add to this figure, cases of paralytic forms of rabies (addition of 20 percent), the estimate increases to 20,565 or 2.06 cases per 100,000. This estimate based on household surveys is slightly lower than the estimates based on projected hospital statistics: 25,000 for the year 1985 and 30,000 for the year 1998 (WHO, 1999). Although not directly comparable, the two sets of numbers are broadly in agreement.

In summary, we conclude that the number of rabies cases per feral dog in India are somewhere between 2.0 and 3.0 per 100,000 persons, or between 93 and 136 cases per 100,000 dogs.

Table 3.3: A decadal hospital incidence of human rabies (clinical epidemiological diagnosis in 22 medical hospitals from 18 states during 1992-2002

Year	Cases	Deaths
1992	876	413
1993	908	373
1994	924	374
1995	933	380
1996	730	340
1997	836	339
1998	791	318
1999	782	313
2000	802	301
2001	707	297
2002	728	304

Source: APCRI(2004)

Table 3.4: Human Rabies Incidence in 22 medical hospitals from 18 states during 1992-2002

	Urban	Rural	Total
Human Rabies Deaths (Number)	56	179	235
Age Distribution (%)			
Children (≤14)	25.5	38.3	35.3
Adults(> 14 years)	74.5	61.7	64.7
Sex Distribution (%)			
Male	72.7	70.6	71.1
Female	27.3	29.4	28.9
Economic Level (%)			
Poor and Low Income	81.9	89.3	87.6
Middle Income	14.5	7.8	9.4
Upper Income	1.8	1.7	1.7
Not Reported	1.8	1.2	1.3

Source: Rabies Survey (2003)

3.2 Costs per dog bite and per case of rabies[3]

APCRI, 2004 estimates that, on average, an animal bite results in 2.2 person days of work lost and the cost of Rs.252 for medicine and visiting the doctor. Assuming that wage loss per day to a worker in India is on the average is Rs.100 (based on India's per capita income at current prices of about Rs. 24,000 during the year 2004-2005) there is a wage income loss of Rs.220 per animal bite. Thus the total cost of an animal bite is Rs.472. However, in reality the cost of Rs. 252 for rabies vaccine and doctors consultation is a subsidized cost by the Government. The market price of rabies vaccine could cost a dog bite victim anywhere between Rs.1500- Rs.5000, resulting in a true cost per bite of between Rs. 1,720 and Rs. 5,220. Therefore while the cost of 1.14 million animal bites in a year in India would amount to Rs. 538.1 million, this figure would increase to a staggering Rs. 3,956 million if the average market price for the vaccine were taken into account. In this report, we work with true costs of drugs, not the costs paid by the victims. The cost taken is the average value of Rs 3,470.

[3] In this section and the next we report costs in Indian rupees. In the final calculations of net benefits, however, we give figures in British pounds. The exchange rate between the pound and the rupee was (rounded to 2dp): 68.14 (2000), 67.95 (2001), 72.98 (2002), 76.14 (2003) and 83.01 (2004) (International Financial Statistics, 2005). In each case the appropriate exchange rate is used in converting rupees to pounds

Goswami et al. (2005) estimate the cost of a rabies case by considering the following costs: transport costs to reach the dog bite centre or the local health centre, nurse administration fees, wound cleaning materials costs, fixed cost treatment for the whole schedule, patient indirect cost, such as the work time lost to reach the vaccination centre, work time lost by waiting before getting the vaccine and work time lost for the vaccine administration for the patient or, if applicable, his/her parent(s), centre overhead cost and the cost of the vaccine. From a private perspective they conclude that the total costs of full post exposure treatment vary between Rs. 1,410 Indian rupees in dog bite centres and Rs. 2,670 Indian Rupees in local health centres. These figures are lower than the true costs of a bite, but they are taken from a private perspective. If the same ratio applies for true, societal, to private costs as for ordinary bites then the true cost would be around Rs 10,000.

For the cases of mortality there are only a few estimates of value of statistical life for the Indian population. Probably the most accurate and recent is that of Madheswaran (2004). He made estimates using a hedonic wages model in which the compensation paid to workers to accept a higher risk of death was calculated. This provides estimates of value of statistical life for the workers in Chennai and Mumbai as Rs.15.4 million and Rs.14.8 million respectively. It is problematic to take these values and apply them to all deaths in India but as there are no other studies, and as these estimates are not out of line from what we would expect from international studies, we believe it is reasonable to take the figures[4]. The only adjustment made to the value of a statistical life is when it is applied to children. Recent studies have shown that, in fact parents are willing to pay more to reduce the risk of death in children and that a ball park estimate is a payment of double the VSL for adults (OECD, 2004). Hence we take a mean value of Rs. 15 million for adults and Rs. 30 million for children.

[4] In the UK, for example, values of statistical life of GBP 2 million have been estimated (reference). The Indian values are about GBP187,500 which are about 9 percent of the UK values. Although per capita income in India is only about 2 percent, the higher ratio of the value of statistical life to per capita income in poor countries has also been found in other studies (Chestnut et al, 1997; Ortiz, 2005).

3.3 Costs of alternatives – Parsi Community

In this section we look at any possible values to be attached to the decline of vultures from a religious perspective. The main impacts are on the Parsi community, a small religious and ethnic group making up less than 0.02 per cent of population of India and living mostly in the cities of Mumbai, Delhi, Lucknow, Ahmadabad, and Hyderabad. The followers of this community are called Parsis because the religion, Zoroastrianism, arrived in India from what was then Persia. The Parsis believe in the existence of one invisible God. They believe that there is a continuous war between the good forces (forces of light) and the evil forces (forces of darkness). The good forces will win if people will do good deeds, think good and speak well. God is represented in their temples through fire, which symbolizes light. The holiest place for them is the village of Udvada in Gujarat, India. The holy language of the Parsis is an ancient language originating in Iran, Avesta.

In order to ascertain the views of Parsis on the extinction of vultures we contacted some important members of this community in Mumbai, Delhi, and Hyderabad during June-July, 2005. We met and interviewed the President and many members of the Parsi Panchayat (assembly) of Mumbai on 29th July, 2005 in Mumbai. A questionnaire was designed explaining the problem of extinction of vultures in India and reasons given by the scientific community for it. Respondents were asked about the value the members of the community place on the services vultures provide to them. A copy of the questionnaire is appended to this report. This questionnaire was circulated to the members of Mumbai Parsi Community two weeks before meeting them. The meeting with the Panchayat started with the following observation from some of the members on the role of vultures and other avian species in disposing the human corpses in their community.

The Parsis believe that fire, water, air and earth are pure elements that need to be preserved. Therefore, they do not cremate or bury their dead, but they dispose the dead bodies on “Towers of Silence”, where the corpses are left exposed to the sun and start to evaporate. The action of the sun is augmented by scavengers, mainly vultures,

followed by crows and hawks. These consume the flesh until only the skeleton remains.

Vultures do not play a role spiritually per se, but are recognised for their practical utility in aiding the disposal of corpses. The Towers of Silence are built on top of hills or low mountains in desert locations distant from population centres. In Mumbai, the Towers of Silence are located in a plot of 53 acres of land in Doongerwadi on a hilltop far from the city. At this site there are 8 solar concentrations installed at a cost of Rs. 200,000 each. In these towers the solar concentrations will produce heat of 120 degrees Celsius, which is sufficient to turn a body into a skeleton in 3 days. The Parsi Community of Mumbai has also obtained permission from the Government of India to maintain an aviary for the conservation of vultures. This has not been created as the community feels that maintaining an aviary of vultures is not feasible due to cost concerns and problems related to food habits of vultures since they would be fed with beef and other meat in aviaries not with human corpses.

The president of the Parsi Panchayat in Delhi observes in a written communication:
"The study is of interest to the Parsi Community, because we Zoroastrians are enjoyed to preserve all God's creations: Mother Earth, man, animals, and the vegetation. The Gyps Vulture is a bird, which provides great service to mankind in keeping clean the environments. It is recognised as valuable link in the chain or creation, destruction and regeneration. It is thus not a 'spiritual value' as you put it, but a recognition of its practical utility, which Parsis recognise.

It may not be equally well known that the Tower of Silence method of the disposal of our dead, in which the Vultures play an important part is practiced only in the original Parsi settlements. Places in what was earlier called the Bombay Presidency and a few other locations viz. Bangalore, Hyderabad and Kolkata have Towers of Silence. The concept of disposal of the dead with the help of birds goes back to Central Asia, the old homeland of the Zoroastrians. It is also followed by Tibetans, and others originating from that region. But even in Iran, the homeland of Zoroastrians, it has fallen into disuse. In most other palces in India, we have 'Aramaghas' where the dead are buried".

In conclusion therefore, personal interviews and interactions with important members of Parsi Cummunity in Mumbai reveal that they do not attach spiritual value to vultures as such but they recognize the practical utility of them as any others from the general public. In response to our questionnaire, all of them said that individually they would not contribute any money for the conservation and protection of vultures for religious motives, but that they might be willing to contribute a significant amount at the Panchayat, or community level of Government, or any other agency that undertakes a program to conserve the vultures as an endangered species that provides a very useful function for the equilibrium of ecosystems. This may suggest that the questionnaire needs to be refined for use with religious communities, who may feel that they are willing to pay but would not be willing to pay the full cost as this would have negative distributional implications on their populations.

In view of this review the only cost associated with the vulture decline from the Parsi community perspective that has been taken into account is the use of the 8 solar concentrations, which amount to Rs 1.6 million.

3.4 Tourism

The opportunity to observe birds and other wildlife has been widely studied in the literature (Boxall et al., 1993; Desvousges, 1993). Researchers have found that the possibility of observing birds and other wildlife positively contributes to the welfare of recreational tourists. People visiting a natural area attach a positive value to the possibility of observing wildlife.

Recently, Becker et al. (2004) have applied non-market valuation techniques, namely the travel cost model and the contingent valuation method to assess the monetary benefits of observing the endangered griffon vulture (*Gyps fulvus)* in Israel. They find that recreational tourists to two reserve areas in Israel, Gamla Nature Reserve and Hai-Bar Nature Reserve, attach a positive willingness to pay for a program that would protect the griffon vulture. The CVM study showed a willingness to pay for protecting vultures of 10.94 Million NIS (£1.03mn) at Gamla and 3.91 Million NIS (£0.48mn) at Hai-Bar. The value of a marginal vulture was estimated at 34,000 to 316,000 NIS (£4,144 to £38,511), depending on the site.

For the present study we do not quantify the benefits of observing vultures from tourists. This would involve a primary contingent valuation study.

3.5 Benefits of Vulture Declines: Airstrikes

The annual impact of vultures in terms of airstrikes was estimated in a paper by Satheesan and Satheesan (2000). Based on accidents between 1980 and 1994, they estimate that the impact of vultures on aircraft may be as high as $70 million per year in India. The authors note that a culling of vultures is not the solution to this problem, and recommend carcass-free zones around airports as an alternative. As the figure is only indicative and somewhat outdated, it has not been included in the formal cost calculations.

3.6 Wider Economic Aspects

Wider economic issues have implications for the successful maintenance of the vulture population. India is one of the fast growing economies in the world now with the rapidly growing demand for the livestock products, milk and milk products, beef, meat, wool and hides. Table 3.5 provides some baseline development indicators for India. The highest growth rate registered by Gross Domestic Product (GDP) at factor cost was 8.5 percent in the year 2003-2004, while the average annual growth has been 5.5 percent during the past ten years.

Table 3.5: Some Socio Economic Characteristics of India

	1951	1961	1971	1981	1991	2001	2003
GDP (million Rs.)	95,470	162,200	422,220	1,301,760	5,109,540	19,029,990	22,548,880
Population (million)	361.088	439.235	548.160	6833.329	846.421	1028.737	
Per capita income	255	350	720	1741	5365	16555	209888
Density of Population (per sq km)	117				267	325	
Literacy Rate (%)	18.3	28.3	34.4	43.5	52.2	65.3	
Life Expectancy (Yrs)	32.1	41.3	45.6	50.4	58.7	65.89	

Source: Economic Survey various reports ,Health Information of India, Central Bureau of Health Intelligence (CBHI), Ministry of Health and Family Welfare (MOHFW), Government of India (GOI), respective years.

A key sector that would influence the sustainability of the vulture population is the livestock sector. This sector contributed 5.4 percent of GDP in India during the year 2002-2003. Table 3.6 provides an overview of the livestock sector in India during the last ten years. During the financial year 2003-2004, it produced 88 million tones of milk, 46.5 million kgs. of wool, and 6 million tones of meat. Milk production in India has increased from 55.7 million tones in 1990-91 to 88.1 million tones in 2003-04 increasing the per capita milk availability from 176 grams per day to 231 grams per day during the same period (Table 3.7). The livestock sector is also an important foreign exchange earning sector, generating Rs.25,680 million from the exports of leather, and Rs. 16,940 million from the exports of meat during the year 2003-2004. The livestock in India has grown at the average annual rate of 1.186 per cent during the period 1951-1997. Despite the slight decline in populations of animals, there is little to suggest that a return to pre-diclofenac populations of vultures could not be sustained, if management practices for the disposal of carcasses were unchanged.

The environmentally sustainable growth of livestock sector requires a growth of vulture population and the growth of vulture population depends on the growth of livestock sector. In this sense the vulture population and livestock sector are endogenous in the system dynamics of the Indian economy.

Table 3.6: Cattle Population and their Growth in India during the period 1951-2003

Species (million nos.)	**1951**	**1956**	**1961**	**1966**	**1972**	**1977**	**1982**	**1987**	**1992**	**1997**	2003*
Cattle	155.3	158.7	175.6	176.2	178.3	180	192.5	199.7	204.6	198.9	178.9
Adult female cattle	54.4	47.3	51	51.8	53.4	54.6	59.21	62.07	64.36	-	93.2
Buffalo	43.4	44.9	51.2	53	57.4	62	69.78	75.97	84.21	89.9	93.2
Adult female buffalo	21	21.7	24.3	25.4	28.6	31.3	32.5	39.13	43.81	-	
Total bovines	198.7	203.6	226.8	229.2	235.7	242	262.4	257.8	289	289.03	272.5
Total livestock	292.8	306.6	335.4	344.1	353.4	369	419.6	445.3	470.9	452.5	
Annual growth rates (%)	**1951-56**	**1956-61**	**1961-66**	**1966-72**	**1972-77**	**1977-82**	**1982-87**	**1987-92**	**1992-97**		
Cattle	0.43	2.04	0.07	0.24	0.19	1.35	0.74	0.48	-0.56		
Adult female cattle	-2.76	1.52	0.31	0.61	0.45	1.63	0.95	0.73			
Buffalo	0.68	2.66	0.69	1.61	1.55	2.39	1.71	2.08	1.36		
Adult female buffalo	0.66	2.29	0.89	2.4	1.82	0.76	3.78	2.28			
Total bovines	0.49	2.18	0.21	0.56	0.53	1.63	1.01	0.94	0.00		
Total livestock	0.93	1.81	0.51	0.53	0.87	2.6	1.2	1.12	-0.78		

Note: * provisional

Source: Agricultural Statistics at a Glance 2003 and17th Indian Livestock Census 2003, Dept. of Animal & Dairying, Ministry of Agriculture, Govt. of India & Past Issues Husbandry

Table 3.7: Estimates of production and per capita availability of Milk in India during 1950- 2004

Year	Milk (million tons)	Per Capita Availability (gm./day)
1950-51	17	124
1960-61	20	124
1968-69	21.2	112
1980-81	31.6	128
1990-91	53.9	176
2000-01	80.6	220
2001-02	84.4	225
2002-03	86.2	230
2003-04	88.1	231

Source: State/UT Animal Husbandry Departments

The growth of cattle population of India has also resulted in an increased number of cattle diseases. Table 3.8 provides data on the incidence of foot and mouth disease cases in India during recent years. The attacks of foot and mouth diseases have increased from 79461 to 116420 during the period 1998- 2003. The increased number of cases of cattle diseases has resulted in the increased use of the anti-inflammatory drug Diclofenac Sodium for treating the cattle. The extinction of some species of vultures in India is related to the presence of this drug in the dead cattle, which left for the consumption of vultures, has resulted in their near extinction. Therefore, the growth of livestock sector with the attending use of Diclofenac Sodium drug has resulted in the decrease in the vulture population in India. Therefore, the modern live stock sector in India has become a cause for the decline of vulture population rather than contributing to its growth. The loss of ecological services from vultures has inflicted the cost on the livestock sector with increased costs of safe disposal of carcasses and the cost to society in terms of health damages, as identified earlier.

The production of beef and buffalo meat for human consumption has been increasing in India as shown in Table 3.9 and

Table 3.10. The production of beef and veal has increased from 0.863 million tons to 1.463 million tons from 1981 to 2002 while the production of buffalo meat has gone up from 0.847 to 1.427 million tons during the same period. Therefore, the production of beef and the production of buffalo meat have respectively grown at 3.04 and 2.61 percent during the period 1981-2001. During the same period, the per capita production of beef and veal has respectively risen from 1.262 to 1.425 kgs while that of buffalo meet has gone up from 1.238 to 1.389 kgs. The rapidly changing food habits of the Indian population, with increased beef and buffalo meat consumption, may lead to an increase in the holdings of livestock and have positive impacts on the sustainability of vulture populations in the region.

Table 3.8: Estimated Foot and Mouth Disease Cases of Livestock in India

		Bovine	Ovine/Caprine	Swine	Buffalo	Sub-Total
	Outbreaks	1814	76	5	14	1909
2003	**Attacks**	116420	5488	83	7140	129131
	Deaths	1956	378	11	110	2455
	Outbreaks	2236	278	10	515	3039
2002	**Attacks**	53632	4559	21	9499	67711
	Deaths	1204	132	1	74	1411
	Outbreaks	2661	21	28	19	2729
2001	**Attacks**	62522	12583	82	6807	81994
	Deaths	1291	208	29	105	1633
	Outbreaks	1519	9	6	3	1537
2000	**Attacks**	35825	568	16	74	36483
	Deaths	237	4	2	0	243
	Outbreaks	1436	32	7	4	1479
1999	**Attacks**	88602	429	346	102	89479
	Deaths	884	72	50	0	1006
	Outbreaks	1100	65	0	0	1165
1998	**Attacks**	79461	5288	0	0	84749
	Deaths	2444	92	0	0	2536

Source: Basic Animal Husbandry 2004, Department of Animal Husbandry and Dairying, Ministry of Agriculture, Government of India.

Table 3.9:Country-wise Production of Beef and Veal in Some Countries of South Asia

	India		Pakistan		Bangladesh	
	Total Beef and Veal ('000 MT)	Per capita Beef and Veal Consumption	Total Beef and Veal ('000 MT)	Per capita Beef and Veal Consumption	Total Beef and Veal ('000 MT)	Per capita Beef and Veal Consumption
1981	863	1.26	195	2.31	123	1.41
1986	949	1.39	248	2.94	135	1.55
1991	1228	1.46	297	2.24	140	1.27
1996	1365	1.46	380	2.87	152	1.38
2001	1463	1.42	428	2.85	173	1.32
2002	1463	1.42	437	2.91	173	1.32

Source : Occasional Paper, National Bank for Agriculture and Rural Development

Table 3.10: Country-wise Production of Buffalo Meat in Some Countries of South Asia

	India		Pakistan		Bangladesh	
	Total Buffalo meat Consumption ('000 MT)	Per capita Buffalo meat Consumption	Total Buffalo meat Consumption ('000 MT)	Per capita Buffalo meat Consumption	Total Buffalo meat Consumption ('000 MT)	Per capita Buffalo meat Consumption
1981	847	1.24	199	2.36	1.79	0.02
1986	1032	1.51	298	3.54	2.39	0.03
1991	1224	1.46	399	3.01	2.99	0.03
1996	1382	1.48	428	3.23	3.5	0.03
2001	1427	1.39	480	3.20	3.5	0.03
2002	1427	1.39	494	3.29	3.5	0.03

Source : Occasional Paper, National Bank for Agriculture and Rural Development

4 Costs of Measures to Recover Vulture Populations

There are two measures being taken to recover numbers: phase out of diclofenac and captive breeding programs. The costs of each of these are presented in this section.

4.1 Costs of moving to alternatives to Diclofenac

4.1.1 Background

In an attempt to protect all the three vulture species from the complete extinction in India, the use of Diclofenac Sodium as a veterinary medicine has to be stopped at once, and replaced with more safe drugs like Meloxicam and Ketoprofen. The Ministry of Environment and Forests, Government of India has made a decision with this effect (Hindu, 3rd March, 2005).

Diclofenac Sodium has been used as an anti-inflammatory and the pain management medicine. The annual production of Diclofenac Sodium in India is about 800 tons, of which 60 percent is exported. This drug constitutes 70 percent of anti-inflammatory and pain management drug use in India. The domestic price of this drug varies from Rs. 400 per kilogram while the export price is in the region of US$ 16 per kilogram.

Meloxicam, a drug recommended by the scientists and the Government of India as a substitute to Diclofenac Sodium is also currently produced and used in India as an anti-inflammatory and pain management drug. Market information shows that it caters to only 2 per cent of market demand. There are approximately 12 to 13

companies producing Meloxicam in India. One of these companies (ALCON Bio Sciences Pvt. Ltd, Mumbai) has provided data of production and the market prices of the drug. This company has produced 550 kgs in 2003 and 1230 kgs in 2004. Exports amounted to 4 kgs and 54 kgs of Meloxicam during the years 2003 and 2004 respectively. The domestic market prices and export prices per kg of Meloxicam are Rs. 4300 and Rs. 6300 for the year 2003 and Rs. 4200 and Rs. 4300 for the year 2004. Therefore, the data shows that the domestic market price of Meloxicam is more than 10 times that of Diclofenac Sodium. Also, the export price of Meloxicam is almost 5 times that of Diclofenac Sodium. However, to calculate the true cost the relative doses of the drugs applied need to be taken into account, and this is done later.

The domestic demand for Diclofenac Sodium will be growing over time in a scenario of non-intervention by the government as the human and cattle population grow in India. Even if we assume that the demand for anti-inflammatory and pain managing drugs in India grows at one percent per year (currently human population and livestock grow at the rates 1.8 and 1.18 respectively in India), we have to replace the current use of Diclofenac Sodium amounting to 320 tones and the corresponding amount with the 1 per cent rate of growth in future by the equivalent or matching amounts of Meloxicam. The substitution of Meloxicam to Diclofenac Sodium may thus involve significant extra cost to the Indian economy.

The comparison between meloxicam and diclofenac, however, is not simple and requires also information on the relative doses. Since meloxicam is longer lasting dose-equivalence is not easy to establish. The pain element we are examining (in cattle) is difficult to assess under similar techniques as the pain elements for humans. However, taking humans as being representative of the pain inhibition of animals, we can use human studies on pain inhibition and relative strengths/doses of these drugs.

Human studies have found the following:

- 15mg meloxicam produced analgesia equivalent to diclofenac 100 mg (Goei The et al, 1997);
- 7.5 mg meloxicam produced analgesia equivalent to diclofenac 100mg slow release (Hosie et al, 1996 and Tavakoli, 2003)

As a consequence of the above, we apply a mid range value of 11.25mg per 100mg diclofenac.

The caveats to this are:

- Human response to pain medication may differ from that of cattle;
- Preparation is important in the dosage used – as diclofenac is prepared in different ways the costs will change; and
- There may be differences in the side-effects of diclofenac and meloxicam.

With the price differential currently of 10.5 times (Rs. 4200 for meloxicam versus Rs. 400 for diclofenac), the implied effective cost difference per dose is therefore 18%.

An alternative measure has also been provided by RSPB, who estimate that the cost difference per dose is about 127%. This is based on the assumption that meloxicam dose is about Rs20-30 per cow while the diclofenac dose is about Rs10-12 per cow.

There is also some evidence that new preparations are falling in price and that has to be allowed for in the cost calculations.

4.1.2 Cost calculation:

Taking the different conversion factors into account, and using the domestic prices of the drugs, we estimate the cost of diclofenac to India of the 320 tons consumed as being Rs128 mn. The comparative cost of meloxicam, given current production costs is between Rs151.2mn and Rs291mn. The net cost of changing to meloxicam is hence between Rs 23.2mn and Rs163mn in the present year. These costs fell at a rate of 2.4% in 2004, but cattle numbers are increasing at a rate of 1.8% per annum.

4.2 Cost of conservation

In the economy without vultures all economic and ecological benefits of carcass disposal and control of feral dog populations etc. are lost. In the real situation of near extinction of vultures in the sub-continent, there is already a problem of irreversibility in the resource management discussed in the environmental and ecological economics

literature. It may not be possible to design any economically feasible program with which we could restore the entire lost populations of all the three species of vultures. The programme of captive holding, breeding and releasing into wild as recommended by BNHS (2004), supported by the Ministry of Environment and Forests, Government of India, could only help to restore 5 or 10 percent of lost populations. The programme is being designed, *ceteris paribus*, with the assumption that the Diclofenac Sodium is the only reason for the extinction of vultures and holding and captive breeding of birds would continue up to the time the use of this drug is phased out and then release them. The number of birds that could survive in the wild could be less and less in future with gradually reducing food supplies. It is important to design the programme in such a way that the number of birds in the wild at a given time is large enough for their survival as a species in the future. That means the objective of this programme is to maintain sustainable number of birds in the wild.

The cost of vulture conservation includes the cost of in house holding and breeding and releasing, and the incremental cost of substituting safe veterinary drugs like Meloxicam and Ketoprofen to Diclofenac Sodium. Also with the humans competing with vultures for the food in the future, there is an opportunity cost of ensuring food supply to the sustainable populations of vultures.

For example, in Pinjore Vulture Care Centre, currently 42 birds are kept with a monthly food cost of Rs 45,000, salaries for a doctor and biologist amounting to Rs. 20000, and salaries for two vulture handlers and driver amounting to Rs. 6,000. Also, a senior ornithologist Dr Vibhu Prakash from BNHS has been regularly supervising this center while the land for the Centre was given by the Government of Haryana. The estimated one time cost and the annual recurring cost of extending this center to house 25 pairs of all three species of vultures are respectively £40,000 and £20,000 (Rs 3.05mn and Rs 1.5mn). Also the estimated one time cost and recurring cost of a new center to house 50 pairs of birds are respectively given as £100,000 and £20,000 (Rs 7.6mn and Rs 1.5mn) (Prakash et al., 2003b). There are proposals to create new vulture care centers in Haryana, Himachal Pradesh, Assam, and West Bengal (BNHS, 2004).

5 Estimating the net benefits of a vulture recovery program

In this section we estimate the costs and benefits of the program to recover the vulture population in India. The following assumptions have been made in deriving the estimates:

I. The analysis looks at a period of 20 years (2005-2025).
II. The current population of vultures in India is 92,431. Studies carried out on 6,355 km identified 883 birds. Given a total length of major roads in India of 665,231 km we obtain the population figure given above for 2001. This excludes village and other roads.
III. The natural growth of the vulture population in the absence of dicofenac is 1.3% per annum (Green et al. 2004).
IV. The captive population is 192, with a growth rate the same as that of the natural population.
V. An increase of vulture numbers by one decreases the sustainable dog population by 0.7; OR an increase in vulture numbers by one decreases the sustainable dog population by 6.79 dogs.
VI. The current population of India is 1.064 billion, and is increasing at a rate of 1.8 percent (World Bank Estimates).
VII. The number of rabies cases per feral dog is 0.001
VIII. The number of cases of dog bite per feral dog is 0.086.
IX. The cost per case of dog bite is Rs. 3470 (£43).
X. The cost per case of rabies (non-death) is Rs. 10,000. (£120)
XI. The cost of a rabies related death is Rs. 15 mn. (adult) and Rs. 30 million (child). The respective values in sterling are £180,700 and £361,400.
XII. The percentage of rabies cases that result in death is 40.
XIII. The percentage of rabies deaths that are children is 35.3.
XIV. The cost of the solar concentrators is Rs. 1.6 million (£19,300). Since these are already built, they will not need replacing if vulture numbers increase enough. We assume the replacement period is beyond the period of the analysis.

XV. The costs of vulture air strikes are excluded because the population is now so low that the issue is not relevant. When numbers increase we assume technology developments and other measures will resolve the problem.

XVI. The costs per kilogram for diclofenac is Rs. 400 (£4.82) while the cost of meloxicam is Rs. 4200 (£50.60) and declining at 2.4 percent per annum.

XVII. The increase in cost per dose equivalent of changing to meloxicam is estimated at EITHER 18% or 127%.

XVIII. The captive programs have a cost of £100,000 for a center for 50 pairs of birds, and annual operating costs of £20,000.

XIX. The discount rate applied to the cost benefit analysis is 10 percent.

The results of the analysis are given in Table 5.1. As the table shows the program is highly justifiable at a ten percent rate of discount with the lower rate of substitution of meloxicam for diclofenac. With the dog/vulture relationship defined in terms of the linear relationship extrapolated from dog and vulture population data the benefits are even higher as the assumed decline in the feral dog population is greater.

If, however, the cost difference between the meloxicam and diclofenac is a factor of 2.27, it makes the net benefits negative with the lower feral dog elasticity. But with the more optimistic assumption about the dog population the rate of return on the program comes out at positive (61%).

Other key assumptions that have not been tested so far are:

a. The present number of vultures.

b. The change in the costs of the substitute drugs as production increases. The present assumption of a decline at a rate of 2.4% p.a. may be insufficient to take account of the economies of scale.

We also noted earlier that some categories of benefits are not included in the analysis – viz. the effects on tourism, the effects on anthrax and water borne diseases and the possible gains to bone collectors.

Overall we conclude that the program is justified. The benefit cost calculations reported above almost make the case on their own. In addition benefits that have not

been included are the existence values, as well as tourism. With these is hard to see how such a program could not be regarded as providing a social benefit.

Table 5.1: Summary of Cost-Benefit Analysis of Vulture Recovery and Diclofenac Substitution

		CASE I	CASE II	CASE III	CASE IV
		D = 1 M = 1	D = 1 M = 2	D = 2 M = 1	D = 2 M = 2
Costs of Program					
Substitution of Diclofenac	£mn.	0.055	13.92	0.06	13.92
Captive Breeding Program	£mn.	0.261	0.26	0.26	0.26
Total Costs	£mn.	0.32	14.18	0.32	14.18
Benefits of Program					
Mortality Benefits	£mn.	4.85	4.85	47.03	47.03
Morbidity Benefits	£mn.	0.21	0.21	2.07	2.07
Total Benefits	£mn.	5.06	5.06	49.09	49.09
Net Benefits	£mn.	4.75	- 9.12	48.78	34.91
Internal Rate of Return	%	49%	N/A	N/A	61%

Assumptions

D = 1	Food assumption: 1 vulture =0.7 dogs
M = 1	100mg diclofenac = 11.25mg meloxicam
D = 2	Linear relationship: 1 vulture= 6.79 dogs
M = 2	Cost base: Meloxicam = Rs25 per dose, Diclofenac Rs11 per dose

Appendix A: A Questionnaire for a CV Survey of Members of Parsi Community in India

Institute of Economic Growth Delhi University Enclave, Delhi 110007.

Valuation of Vultures by Parsi Community: A CV Survey

I Description of public good: Vulture

The rapid decline in the population of Gyps vultures in India and other parts of the sub-continent has led to concerns as to the reasons for these declines and the socio economic consequences associated with a fall in the number of vultures. Vultures are significant spiritually, economically and environmentally in terms of their ability to dispose of human and animal remains. The report of the International South Asian Vulture Recovery Workshop (2004) identified the following 7 potential causes of rapid vulture population decline:

1. Loss of nesting habit
2. Infectious diseases
3. Use of veterinary drugs
4. General environmental contamination
5. Deliberate poisoning of carnivores leading to secondary poisoning of vultures
6. Low food availability
7. Exploitation and persecution

Recent scientific investigations about the causes of vulture decline lend support to the theory that use of veterinary drugs especially Diclofenac Sodium, a non-steroidal anti-inflammatory drug administered to the domesticated cattle in the Indian sub-continent, is significant in the decline of vulture populations.

1) Are you already aware of these developments about vultures in India?
   Yes ☐ No☐

2) If yes how you come to know?
   Parsi Community ☐
   News Papers, TV and Radio ☐

Practical observation at certain sites where vultures normally found ☐

II Motivating the respondents to place the value on the Vultures as a Natural Resource: Spiritual values

Vultures have religious and spiritual significance for Parsees and Hindus. Parsees dispose dead bodies by offering them to vultures as for example Towers of silence in Mumbai. The extinction of vultures has denied the Parsee population their traditional way of disposing their dead. The impacts of the extinction or near extinction of the Gyps vultures in India may be significant in terms of the spiritual well-being of the Parsees both in India and abroad. The consequential impacts include:

- loss of welfare in terms of spiritual benefits of knowing that their remains will be disposed of in a way consistent with Zoroastrian faith, which does no allow defilement of the dead and the fact that the Parsees cannot cremate, bury or submerge their dead in water as they consider a corpse impure;
- additional costs of disposal of remains eg the use by the orthodox Community of solar reflectors to hasten decay of the bodies or the creation of "vulture centres" to enable disposal in keeping with tradition.

Health impacts

Absence of vultures could lead to increase in the resident feral dog populations feeding on dead cattle with serious consequences for human and wildlife health in terms of increase in the incidence of rabies.

Livestock Industry

Vultures could be regarded as natural resources providing waste disposal services, disposing carcasses of dead cattle which are regarded as waste emanating from the agricultural and dairying activities.

The consequential impacts on the livestock industry may be:

- increased cost of disposal of animal carcasses;
- increased incidence of disease due to corpses remaining exposed for longer periods than previously was the case, and
- increased costs in terms of use of by-products of bones and carcasses.

Tourism

The benefits derived by tourists from seeing vultures have not been examined in any great depth to date. There is some evidence of willingness to pay to see vultures in captivity, in that some breeding centres have had visitors.

3) Is extinction of vultures a cause of concern for Parsi Community?

   Yes ☐ No ☐

4) What alternative methods are possible to perform the religious function of disposing dead in your Community in the absence of vulture?

   _____

III Elicitation of preferences of people for Vultures:

Reduction of all three species of vulture population by as much as 99 percent as observed shows that we are at the brink of irreversibility of these species. Any neglect of immediate intervention could result in the extinction of these birds.

Remedial measures:

1. The use of Diclofenac Sodium as a veterinary medicine has to be stopped at once, and replaced with meloxicam and ketoprofen. The Ministry of Environment and Forests has already taken a decision with this effect (Hindu, 3rd March, 2005). The objective of conservation programme is to ensure the survival of ecologically sustainable number of all three species of vultures (it could be only 5 percent of original population) and could serve the interests of Parsee Community.
2. Captive Breeding: The cost of vulture conservation include the cost of in-house holding and breeding and releasing, and the incremental cost of substituting safe veterinary drugs like meloxicam and ketoprofen to Diclofenac Sodium. There is currently small breeding center at Pinjore which contains 42 vultures, and annual maintenance of this center is approximately 10 laks. The estimated one time cost and the annual recurring cost of extending this center to house 25 pairs of all three species of vultures are respectively 32 laks and 16 laks (approx). Also the estimated one time cost and recurring cost of a new center to house 50 pairs of birds are respectively given as 80 laks and 16 laks (approx).

Alternative disposal methods of dead by Parsi Community involve cost to the Community. There is also significant cost in maintaining aviaries of vultures to the Community.

If you have to contribute annually some money for the conservation of vultures, will you be interested to pay to

(a) Government ☐ (b) A Nongovernmental Organization (NGO) ☐

(c) A voluntary organization to which you are also a member ☐

How much you are willing to pay annually on behalf of your family to restore the lost population of vultures in India, so that the Parsi Community is not affected in their religious and spiritual values.

Rs._____

Over and above your interest as a member of the Parsi Community, Do you also think that Vultures are an important bird species and there should not be allowed to be extinct?

Yes ☐ No☐

If yes, how much you are willing to contribute annually on behalf of your family for a conservation program to preserve these bird species

Rs._____

IV Socio Economic Characteristics of Household:

i) Name of the Respondent:

ii) Age

iii) Education: a) School ☐ b) College ☐ c) University ☐

iv) Occupation: a) Business ☐ b) Salaried ☐ c) Any other ☐

v) Family Size:

vi) Annual Income:

Appendix B: State wise Registered Dog Bite cases and Death cases during 1997-2001

States/Uts	Rabies/Dog-Bites 1997		Rabies/Dog-Bites 1998		Rabies/Dog-Bites 1999		2000	2001
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases/Deaths	Cases/Deaths
Andhra Pradesh	375	78	377	104	577	70	61	33
Arunachal Pradesh	0	0	NR	NR	-	-	-	-
Assam	148	4	36	0	-	-	-	-
Bihar	-	-	NR	NR	-	-	-	-
Goa	1	2	0	7	0	2	0	3
Gujarat	31	2	5	1	29	8	60	21
Haryana	3	0	1	0	-	-	0	0
Himachal Pradesh	0	0	2	1	0	0	0	0
Jammu & Kashmir	479	@	142	@	271	0	0	0
Karnataka	7125	34	9205	36	1032	34	43	68
Kerala	62	5	106	16	249	18	11	10
Madhya Pradesh	596	4	423	0	29	0	0	1
Maharashtra	130	130	69	69	73	73	70	84
Manipur	0	0	0	0	0	0	1	0
Meghalaya	264	0	398	0	251	0	0	1
Mizoram	0	0	1	0	1	0	0	0
Nagaland	66	0	210	2	62	0	0	0
Orissa	160	8	159	9	-	-	8	4
Punjab	-	-	0	0	-	-	0	0
Rajasthan	1953	5	722	3	346	4	9	5
Sikkim	0	0	50	0	31	0	0	1
Tamil Nadu	111	5	70	13	66	9	1	0
Tripura	0	0	21	2	15	2	0	0
Uttar Pradesh	95	93	245	91	48	2	4	0
West Bengal	262	262	188	188	-	-	198	251

States/Uts	Rabies/Dog-Bites 1997		Rabies/Dog-Bites 1998		Rabies/Dog-Bites 1999		2000	2001
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases/Deaths	Cases/Deaths
Andaman & Nicobar Islands	0	0	0	0	0	0	0	0
Chandigarh	1	0	NR	NR	-	-	0	0
Dadra & Nagar Haveli	0	0	1	0	0	0	-	-
Daman & Diu	0	0	0	0	0	0	0	0
Delhi	198	18	138	18	4	1	0	2
Lakshadweep	0	0	0	0	0	0	0	0
Pondicherry	11	5	6	6	1	1	7	6
India	12071	655	12575	566	3085	224	473	490

Source: Lok Sabha Unstarred Question No. 3448, dated 14.08.2000, Indiastat.com.

References

Agricultural Statistics at a Glance, Livestock census, Ministry of Agriculture, GoI, New Delhi

Association for Prevention and Control of Rabies in India (APCRI, 2004),"Assessing Burden of Rabies in India: Report of the National Multi-Centric Rabies Survey", May 2004, Bangalore, India.

Becker, N., Y. Choresh, and M. Inbar (2004) "A Bio-Economic Valuation of Protecting Vultures: Estimating the Economic Benefit of Viewing Vultures (Gyps fulvus) and some policy implications of valuation techniques," paper presented at the Conference "Economics and the analysis of Biology and Biodiversity", 2-3 Sept. 2004, Kings College, Cambridge, UK.

Bombay Natural History Society,"Report of the International South Asian Vulture Recovery Plan Workshop", 2004.

Boxall, P.C., W.L. Adamowicz, P. Swait, M. Williamns and J. Louviere (1993) "A comparison of stated preference methods for environmental valuation," Ecological economics, 18(3), 243-53.

Chestnut, L.G, B.D. Ostro and N.V. Vadakan (1997), 'Transferability of air pollution control health benefits from the United States to developing countries: evidence from the Bangkok study', *Ameerican Journal of Agricultural Economics,* 79 (5), pp1630-1635.

Cunningham, A.A. Prakash, V., Pain, D.J. Fhalsasi, G.R., Wells, G.A.H., Kolte, G.N., Nighot, P., Goudar, M.S., Kshirsagar, S. and A. Rahmani (2003), "Indian Vultures: Victims of an infectious disease epidemic?" *Animal Conservation.* 6, 189-197.

Central Bureau of Health Intelligence (CBHI), New Delhi.

Chhabra, M. Ichhpujani RL, Tewari KN and S. Lal (2004) "Human Rabies in Delhi" *Indian Journal of Pediatrics* Volume 71, Issue 3, pp217-220.

Department of Animal Husbandry and Dairying, Ministry of Agriculture, GoI, New Delhi

Desvousges, W. H., F. R. Johnson, R. W. Dunford, K. J. Boyle, S. P. Hudson and K. N. Wilson (1993), 'Measuring Natural Resource Damages with Contingent Valuation: Tests of Validity and Reliability', in J. A. Hausman, ed., *Contingent Valuation: A Critical Assessment*. Amsterdam: North-Holland, pp. 91–164.

Economic Survey (various reports), Ministry of Finance, GoI, New Delhi

Goei The HS, Lund B, et al. A double-blind, randomized trial to compare meloxicam 15 mg with diclofenac 100 mg in the treatment of osteoarthritis of the knee. Osteoarthritis Cartilage 1997; 5:283–288.

Goswami A, Plun-Favreau J, Nicoloyannis N, Sampath G, Siddiqui MN, Zinsou JA. (2005) "The real cost of rabies post exposure treatments," *Vaccine*, 23, 2970-76.

Green, R. Newton, I. Shulz, S., Cunningham, A.A., Gilbert, M. Pain, D.J. and V. Prakash (2004) "Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent," Journal of Applied Ecology, 41, 793-800.

Hosie J, Distel M, et al. Meloxicam in osteoarthritis: a 6-month, double-blind comparison with diclofenac sodium. Br J Rheumatol 1996; 35(Suppl 1):39–43.

Johannson, P.O. (2002) "The value of a statistical life: Theoretical and empirical evidence," *Applied Health Economics and Health Policy*, 1(1), 33-41.

Ministry of Health and Family Welfare(various reports), GoI, New Delhi

Madheswaran, S.(2004), "Measuring the Value of Life and Limits: Estimating Compensation, Wage Differentials among workers in Chennai and Mumbai" South Asian Network for Development and Environmental Economics (SANDEE), Kathmandu, Nepal.

Markandya, A. and M. N. Murthy (2000) *Cleaning up the Ganges*. Oxford University Press, India.

Markandya, A., L. Bellu, V. Cistulli and P. Harou (2002) *Environmental Economics for Sustainable Growth: A Handbook for Practitioners*, Edward Elgar, Cheltenham, UK.

Mrozek, J. R. and L. O. Taylor (2002) "What Determines the Value of Life? A Meta Analysis," *Journal of Policy Analysis and Management*, 21(2), 253–70.

National Bank for Agriculture and Rural Development(Occasional papers), Mumbai.

National Institute of Communicable Diseases (NICD), New Delhi

Oaks, J.L. (et al) (2004), " Diclofenac Sodium residues as the cause of population decline of vultures in Pakistan", Nature. 427, 630-633.

OECD (2004) *The Valuation of Environmental Heath Risks to children: Synthesis Report.* Working Party on National Environmental Policy. Environment Directorate, Report ENV/EPOC/WPNEP(2004)15. Organisation for Economic Co-operation and Development (OECD), Paris.

Ortiz, R. (2005), Valuation of Mortality Risks Associated with Air Pollution: A Case Study for Brazil, submitted PhD thesis to the University of Bath.

Pain, D., A. A. Cunningham, P. F. Donald, J. W. Duckworth, D. C. Houston, T. Katzner, J. Parry-Jones, C. Poole, V. Prakash, P. Round, R. Timmins (2003) "Causes and effects of temporospatial declines of Gyps vultures in Asia," Conservervation Biology 17, 661–671.

Prakash V. (in prep) "Recent population trends of Gyps bengalensis, Gyps indicus and Gyps tenuirostris in India".

Prakash, V., Pain, D.J., Cunningham, A.A., Donald, P.F., Prakash, N., Verma, A., Gargi, R., Sivakumar, S. and Rahmani, A.R. (2003a), "Catastrophic collapse of Indian white-backed Gyps bengalensis and long-billed Gyps indicus vulture population". *Biological Conservation.* 109, 381-390.

Prakash, V. Pain, D.J. Shulz, S. and A.A. Cunningham (2003b), "Saving Asia's Gyps Vultures: The Vulture Rescue Team's Conservation Programme", Proceedings of the WWGBP, Budapest, Hungary, May.

Tavakoli M. Modelling therapeutic strategies in the treatment of osteoarthritis: an economic evaluation of meloxicam versus diclofenac and piroxicam. Pharmacoeconomics, 2003;21(6):443-454.

Prakash, V. (et al) (2001), "Socio-economic impact of the crash in Vulture Population in Bharapur District, Rajasthan", BNHS.

Risebrough, R.W. (2000), "Population Crash of the Gyps Vultures in India: Evidence for a disease factor and recommendation for emergency efforts", The US Fisth & Wild life Service, USA.

Risebrough, R. (2004) "Conservation biology: Fatal medicine for vultures," *Nature* 427, 596-598.

Satheesan, S and M. Satheesan (2000) "Serious Vulture Hits to Aircraft Around the World". Paper prepared for International Bird Strikes Committee, Amsterdam 17-21 April 2000.

Shanmugam, K.R. (1996), "The Value of Life : Estimates from Indian Labour Market" *Indian Economic Journal*, 44(4), 105 – 114

Shultz, S. (et al.) (2004), "Diclofenac Sodium poisoning is widespread in declining vulture populations across the Indian subcontinent", Biology letters, The Royal Society.

Schüz, E., and C. König (1983) "Old World vultures and man," in S. R. Wilbur and J. A. Jackson (eds.) "Vulture biology and management," University of California Press, Berkely.

The Hindu, " Meet to focus on dwindling vulture population", 14th March, 2005.

United National Development Programme (various reports), Washington.

Viscusi, W.K., and J.E. Aldi (2003) "The value of a statistical life: a critical review of market estimates throughout the world," *NBER Working Paper* 9487.

Viscusi, W.K. (2000) "The value of life in legal contexts: surveys and critique," *American Law and Economics Review*, 2(1), 195-222.

World Health Organisation (various reports), New Delhi.