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RESEARCH ARTICLE

Costs of Biodiversity Restoration: A Case Study of Okhla Bird Sanctuary

Abhishree

TERI School of Advanced Studies

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Abstract: The continued expansion of the human population and the growth of per capita consumption has resulted in an unsustainable exploitation of the biological diversity present on Earth. Effective strategies of conservation are vital to the survival of the human species. Safeguarding the biodiversity habitats including wildlife sanctuaries, national parks and biosphere reserves plays a crucial role here. Successful approaches of conservation require adequate investment directed towards restoring these areas. On the contrary, these protected areas are at various stages of degradation due to several anthropogenic pressures. This presents a conundrum wherein the twin goals of any society conflict with each other. Prioritisation of economic growth would compromise environmental conservation and vice versa. The Okhla Bird Sanctuary is one such example of a protected area. Tremendous anthropogenic pressure over the years in the form of increasing development activities and pollution discharge in the wetland has led a decline in the number of the bird species. In this study, we conduct an opportunity cost analysis of restricting the activities that are posing threat to the wetland and the sanctuary. GIS based tools are employed to demarcate an eco-sensitive zone around the sanctuary within which major development projects are prohibited. The future revenue stream for the services forgone is discounted and calculated along with the estimated market value of the land in the no-development zone to arrive at the opportunity cost.

The study found out an opportunity cost of INR 5,192 crores at 2020 prices. A monetary valuation of restoring ecosystem services serves as a guide to policymakers to find a win-win solution to the development versus environment puzzle. A sustainable future requires a wider lens to not view this issue as a zero-sum game rather follow an integrated approach incorporating the precautionary principle.

Keywords: *Biodiversity Restoration, Ecological Sensitivity, Opportunity Cost Analysis, Okhla Bird Sanctuary*

1 INTRODUCTION

The term biodiversity can be best understood as the stock of all the species existing presently on Earth, variations within species, and the interaction among them as well as with their biotic and abiotic environment. The subject of biodiversity conservation has been in the eye of the storm for a long time primarily due to the debate between ecologists and economists. Ecologists believe that biodiversity is of crucial significance to the health of all the ecosystems in the world and to the survival of the human species on the planet Earth. Economists, on the other hand, view biodiversity as any other market good which can be substituted by other commodities. The mistake frequently committed by economists lies in the narrow definition of value. They measure value by the relative price of commodities as determined by market exchange (Gowdy 1997).

Thus biodiversity, which often lacks a market, is either not valued at all or often undervalued. It is becoming increasingly recognized that biodiversity conservation needs to be integrated with social and economic development in contemporary policies of conservation.

One such case where this trade-off can be witnessed is the Okhla Bird Sanctuary. The sanctuary, situated in Gautam Buddha Nagar district of Uttar Pradesh, is one of the 466 Important Bird Areas in India. Spread over an area of 4 sq. km (400 hectares), the most prominent feature of the sanctuary is a wetland inhabiting an area of almost 273 hectares (more than 68% of the total area). This water body is the main attraction for the migratory and resident birds as the herbaceous vegetation growing amidst the water provides appropriate fodder and resting ground for them. However, residential, and commercial construction has severely impacted the biodiversity of the sanctuary which has resulted in a decreasing population of birds over the years.

To prevent further ecological damage to such areas of biological importance, the MoEFCC recommended a 10 km buffer zone around protected areas in 2002. However, due to the concern that large human habitations would fall under this purview, the National Board of Wildlife in 2005 decided that the decision would be site-specific and involve regulation rather than prohibition of activities. The National Green Tribunal, in 2013, ordered all the construction work within a radius of 10 km around the Okhla Bird Sanctuary to be stopped immediately. This affected a lot of upcoming housing projects in Noida. Following this, MoEFCC issued a notification in August 2015 delineating an area of 100 meters from the eastern, southern, and western boundary and 1.27 km from the northern boundary of the sanctuary as the eco sensitive zone.

Whenever two goals conflict, opportunity costs arise attached to each development activity. The primary component of this research entails identifying the opportunity costs of restoring biodiversity in the sanctuary. This will pertain to elucidating the opportunity costs of not allowing development activities up to a certain area around the sanctuary utilizing tools of the Geographic Information System.

1.2 Objectives and Research Question

The first objective of the study is to determine the opportunity costs of restricting development activities around the Okhla Bird Sanctuary. This encompasses determining the losses faced by the society if no residential and/or commercial construction is allowed within a specified area from the boundary of the sanctuary.

An additional scope of the study includes assessing the ecological sensitivity of the area by using LULC and NDVI maps. This will highlight the importance of investing in the restoration of the place as monetary funds are limited and need to be spent appropriately by prioritizing certain aspects.

Therefore, based on the objectives listed above, **the research question** is: What are the costs of biodiversity restoration in the Okhla Bird Sanctuary?

2 LITERATURE REVIEW

The reasons for degradation of the Okhla Bird Sanctuary which include turning the place into a concrete jungle, household and industrial pollution load in the River Yamuna, and disturbance by the local villagers are also mentioned by Urfi (2003). With problems known transparently, one must try to locate solutions and their related costs by undertaking an exhaustive review of the literature.

Gagné and Fahrig (2010) study the impact of housing development on forest breeding birds. The authors evaluate the trade-off between sprawl area and housing density by utilizing data on bird species, richness, abundance, and evenness in Ottawa, Ontario, Gatineau, Quebec, and Canada. Breeding birds in same size sites (representing housing densities) were counted and subsequently, four hypothetical development scenarios were constructed. Scenarios depicting varying densities resulted in dispersed, semi-compact, and compact development patterns. Consequently, the housing density that minimized the negative impact on breeding birds was identified. Four categories were defined based on dwellings/km2: Forested, Exurban, Suburban, and Urban. The results of this paper suggest that clustering developments in urban densities (140-712 dwellings per km2) minimize the impact of a given human population on forest breeding birds.

Prakash et al. (2018) employs the technique of GIS and remote sensing to delineate eco-sensitive zone around the Jhilmil Jheel Conservation Reserve using a species centric approach. Taking Swamp deer as the focal species, the Maxent tool, based on the maximum entropy model, was used for determining its suitable habitat. The swamp deer presence data was taken as an input while the other variables included were altitude, NDVI, LULC, and road network. The NDVI and LULC came as the top two factors contributing to the decision of demarcating the eco-sensitive zone. This zone constituted a minimum periphery of 1 km to a maximum of 10 km around the reserve with a total area of 307 sq. km.

Another application of GIS and the concept of ecological sensitivity was put forth by Liang and Li (2012). The authors studied the Yellow River Delta Natural Reserve in China by dividing the area into grids of 200 x 200 m. Beginning with prioritizing the endangered water birds and identifying their habitat preference, the paper goes on to calculate a comprehensive habitat suitability index which builds on other indexes like species conservation index, fragmentation index and the proximity index of each habitat type. Further, cranes were selected as the indicator species and its habitat loss rate due to anthropogenic disturbances was analysed. The overall ecological sensitivity of the area was found to be quite high especially in the coastal regions with extreme and fair sensitivity areas accounting for 55.74% of the total area.

Drawing a perfect connection from learning about these nuisances to solving them is not easy. Resources required for biodiversity conservation are limited and so arises the need for strategic investment. A less opaque understanding of the costs of safeguarding ecosystems will lead to an efficient allocation of these scarce resources (Naidoo and Ricketts 2006). Most studies on conservation planning use partial estimates of costs since full accounting is not always possible.

In some instances, surrogate measures of costs are required. Apart from the immediate costs of conservation, opportunity costs serve as an adequate measure of the social costs of preserving protected areas (Adams et al. 2010).

Moving further to landscapes like our study area, the opportunity costs of restricting development around coastal wetlands have been assessed by Batie and Mabbs-Zeno (1985) and Parsons and Wu (1991). The developmental value of converting these wetlands into housing lots on the Eastern coast of Virginia has been estimated. Changes in land value are equated to changes in development benefits within a given land parcel. The marginal returns to the development of wetlands were estimated by using the hedonic price model by relating the lot prices to the lot characteristics for a sample of lots. The gross costs were calculated using engineering estimates for converting the wetlands into filled lots. The net marginal returns, labelled as the opportunity cost, are the values obtained after deducting the marginal costs to development (land purchase costs) from the private income from development. The total developmental value for 58 acres of this wetland came out to be $31,890,000. This kind of development valuation framework could assist in making policy decisions when data relating to all the social costs and benefits from natural resource use is lacking (Batie and Mabbs-Zeno 1985).

A similar analysis is done for the Chesapeake Bay using certain coastal land-use restrictions in which development is restricted in a 1,000-foot buffer zone around the water. As in the previous study, a hedonic price model is employed using data from a housing market like the one where these controls are established. The number of houses that would have been built in this area without controls is predicted and marked as the displaced houses. Further, the lost value of no longer enjoying the unique amenities of the coast is calculated using the regression. This is termed as the “opportunity cost of displacement” (Parsons and Wu 1991).

The above two studies can be modified and applied to the research problem at hand. Since the Okhla Bird Sanctuary is a protected area and people cannot enjoy the same benefits from it as the coastal areas, the hedonic price model is not going to work. The alternate estimate of the lost amenities would be the value of land getting affected for which the market price of land can be taken as a proxy indicator.

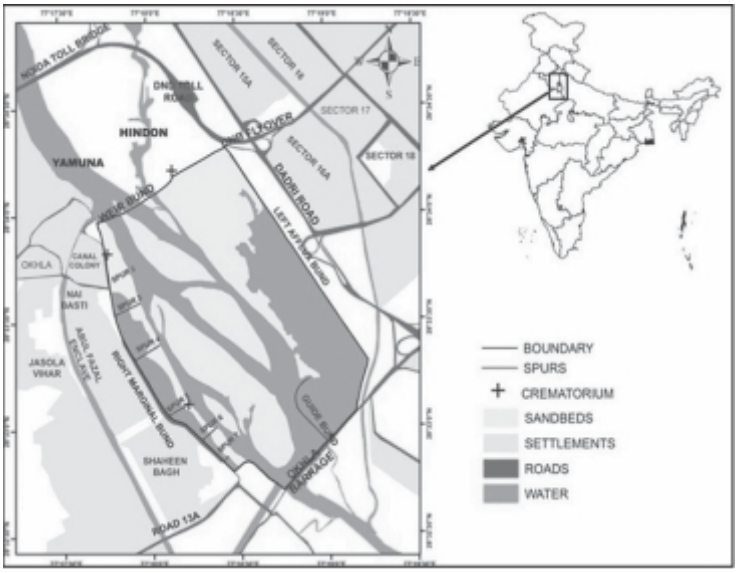
Literature Gap: Even though the concepts of opportunity cost and ecological sensitivity have gained much popularity, there has not been any study in the Indian context that assesses the opportunity costs of restoring protected areas utilizing GIS. None of the research works particularly make use of any restriction guidelines related to development activities in densely populated areas and then calculate the losses faced by society. This study aims to fulfil the above literature gaps and undertake a holistic approach towards restoring biodiversity where the opportunity costs are merged with the other kinds of infrastructural costs. Also, since most of the studies are focused on determining the ecological sensitivity of large reserves, this study is an attempt to not neglect small protected areas in urban landscapes which also require protection.

3 DATA AND METHODOLOGY

To explain a method, it is crucial to understand the objective behind it. A mixed-method has been applied to the current study. Focus group discussions in the month of January with the sanctuary staff and visitors helped to narrow down the main anthropogenic pressures discussed in the introduction. Opportunity cost analysis is used to ascertain the losses faced by society by restricting developmental activities around the Okhla Bird Sanctuary.

3.1 Study Area: Okhla Bird Sanctuary, situated in Gautam Buddha Nagar district of Uttar Pradesh, is one of the 466 Important Bird Areas in the country. The geographical extension of the sanctuary lies between 28°32′43.5″N and 28°32′56.3″N latitudes and 77°18′41.7″E and 77°18′56.6″E longitudes. It is situated at a point where the Yamuna River leaves the state of Delhi and enters Uttar Pradesh. Spread over an area of 4 sq. kilometres, it is home to around 302 species of migratory and resident birds. Out of the 400 hectares of the sanctuary, 273 hectares comprises of a wetland. The sanctuary is a huge alluvial plain with a south-eastern slope. Its altitude is about 200 meters above sea level. Figure 1 below depicts the study area. The wetland, along with the Yamuna River, receives flow from the Hindon River which travels through six districts of Uttar Pradesh before falling into the wetland.

Figure 1: Map of the Study Site

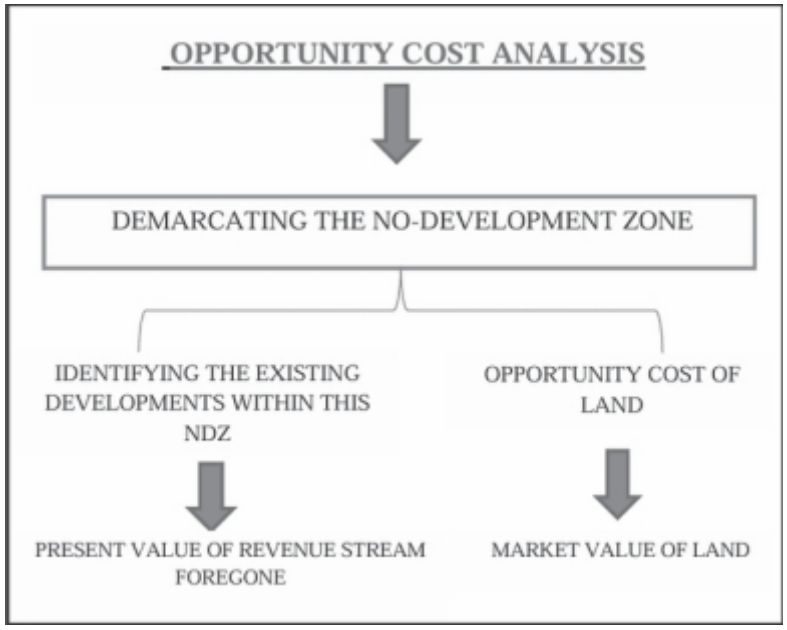


In decisions involving an optimal choice of delineating land for conservation in protected areas, conservation biologists have incorporated the opportunity costs of achieving a given result (Chomitz et al. 2005).

To determine the cost of restoring the biodiversity in our sanctuary, it is crucial to consider the foregone alternatives. With regulation or public land, direct financial payments may be separated from the value of lost opportunities. From the perspective of society, it is critical to track the complete set of conservation consequences by including the opportunity costs (Ferraro et al. 2006).

Further, given budgetary constraints and the problem of adverse selection, calculating estimates of the opportunity costs which are spatially explicit represents a higher research priority than placing a monetary value on the services provided by biodiversity (Ferraro 2011). The components of this cost include the income foregone from commercial development, loss of output due to restricting exploitation of natural resources, loss of opportunities for job creation et cetera. Also, the market price of land reflects the restrictions imposed upon future land uses and is thus taken as an estimate of the net present value of the future revenues lost.

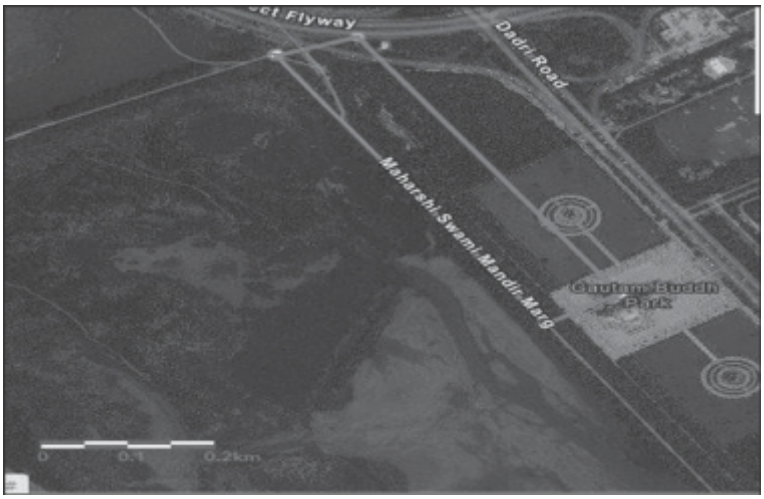
Figure 2: Theoretical Framework of the Opportunity Cost Analysis



Source: Author's self-compilation

As can be seen from the Figure 2 above, the opportunity cost analysis entails delineating a no-development zone around the sanctuary and then estimating the consequent losses. These losses include calculating the present value of the revenue stream which is lost if the future use of a particular development site is prohibited. The second aspect is the opportunity cost of land which is estimated by taking its market price as a proxy which depicts the future value of the land. The decision of demarcating the restricted zone is based on recommendations proposed by expert committees. After a certain limit is defined, the area is outlined using techniques of the GIS and commercial/residential establishments are identified. The area of the no-development zone is calculated in ArcGIS 10.3 by constructing line segments of length 100 meters from all the boundaries of the sanctuary as depicted in Figure 3 below.

Figure 3: Delineating NDZ using GIS



Source: ArcGIS 10.3

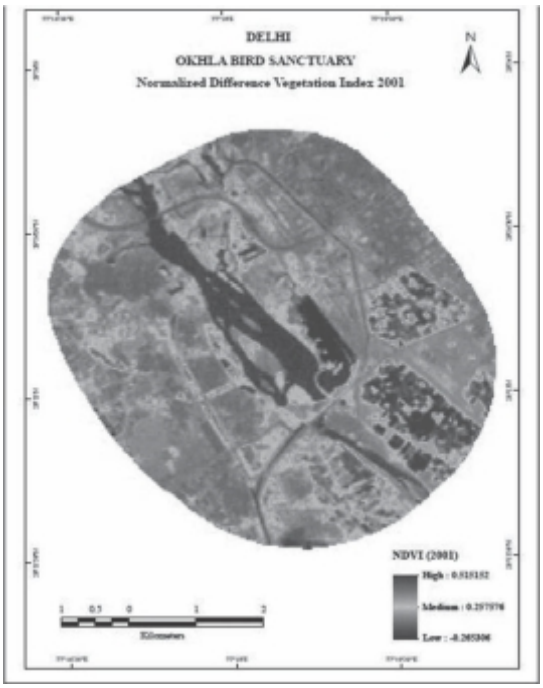
3 RESULTS AND DISCUSSION

3.1 Analysing changes in Vegetation and Land Cover

The primary step in this analysis comprises generating the NDVI of the sanctuary. The satellite images (Landsat 4-5TM C1 level) of the sanctuary and a 2 km buffer around it were downloaded for the years 2001 and 2018. These images were then classified using ERDAS IMAGINE software where the colour bands were used to classify different categories of areas on the image ranging from high to low density of vegetation. Further, ArcGIS 10.3 was used to create an NDVI map for the two respective years depicting the density of vegetation observed around the study area as shown in Figure 4 and Figure 5 below. The NDVI quantifies the vegetation by estimating the difference between the light that vegetation strongly reflects (the near-infrared or NIR) and the light that it absorbs (red light). The mathematical formula for calculating NDVI can be deduced from equation 1 below. NDVI = (NIR + Red)/ (NIR - Red) (1) The values of NDVI generally range from -1 to 1 with positive values denoting dense vegetation.

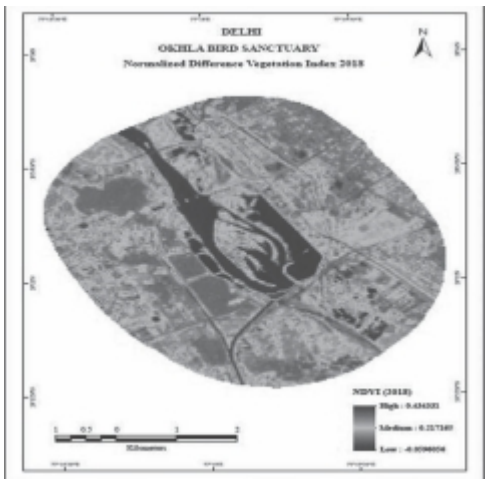
As deduced from Figure 4 below, the NDVI value for the year 2001 is around 0.51. A higher value typically represents healthier and dense vegetation as it absorbs most of the visible light that hits it. The low value takes on the red colour and a value of -0.26 which generally depicts the water bodies.

Figure 4: NDVI Map for 2001



Further, Figure 5 below depicts this same NDVI but for the year 2018. The map underneath depicts an NDVI of 0.43 in the high-density category. The dark green colour in certain areas has lightened over time as compared to 2001. Overall, the NDVI has declined by almost 15.6% from 2001 to 2018.

Figure 5: NDVI Map for 2018



3.2 Opportunity Costs of Restoration

The importance of taking opportunity costs into account when calculating the costs of biodiversity conservation has been highlighted by several economists. This category of costs includes forgone economic activities or alternate uses of resources at a particular site. Making them explicit will improve the decision-making process and put the financial resources to more efficient use. Quantifying these opportunity costs where compensation is not paid is seen to be difficult and a qualitative assessment is preferred. The authors state different components of opportunity costs arising out of the development restrictions. These include loss of income from forgone development, loss of socio-economic opportunities, forgone opportunities for job creation, and restricting output on the exploitation of natural resources.

Another criterion for regulating activities in buffer zones of protected areas was proposed by the Central Empowered Committee. This committee, constituted by the Supreme Court in 2002, has proposed safety zones for protected regions by categorizing them according to their spatial area. CATEGORY A – If the area is more than 500 sq. km, then the committee proposes a safety zone of 2 km. CATEGORY B – Similarly, if the area is between 200 sq. km and 500 sq. km, then that protected area ought to have a safety zone of 1 km CATEGORY C – If the area is between 100 sq. km and 200 sq. km, a safety zone of 500 meters is proposed. CATEGORY D – Lastly, areas up to 100 sq. km should have a safety zone of 100 meters. As deduced from above, the Okhla bird sanctuary falls into Category D with an area of 4 sq. km. Thus, we can demarcate 100 meters each from the northern, southern, eastern and, western boundary as the no-development zone using the GIS techniques explained in the methodology chapter.

The opportunity cost of not allowing any development activities in this 100-meter zone can be segregated according to the four boundaries. All the boundaries except the northern boundary have some form of either a commercial or residential construction. The north side of the sanctuary consists of the Yamuna River floodplains. The cost here will be only the foregone market value of the land. Western Boundary The western boundary is the most densely populated with Abul Fazal Enclave and Canal colony spread out along its 2 km length as can be seen from the figure below.

Figure 6: Satellite Image of the Sanctuary

Source: ArcGIS 10.3

The population residing in this zone would need to be displaced if the no-development guideline is implemented. Thus, the number of people falling in the no development zone along this boundary can be seen as a social cost arising out of biodiversity restoration. The area of both the colonies and the NDZ is estimated using the GIS techniques explained previously. The population statistics are obtained from the Census of 2011. Equation 2 below represents the formula for calculating the number of displaced people.

Number of people residing in the NDZ = (Population per sq. km) * (Area of the NDZ)

where Population per sq. km = Total population of colony/ Total Area of colony

Table 1 below depicts the estimates found by applying the equation above. A total of 9,871 people are found in the NDZ of 0.22 sq. km along the western boundary.

Table 1: Calculation of Population residing in the No-Development Zone

Name of colony	Area (sq. km)	Total Population	Population per sq. km	Area of NDZ (sq. km)	Population in the NDZ
A	B	C	D = (C/B)	E	F = (D*E)
Abul Fazal Enclave	1.13	60,886	53,881	0.18	9,698 people
Canal Colony	0.11	475	4,318	0.04	173 people
TOTAL				**0.22 sq. km**	**9,871 people**

The monetary counterpart of this figure is the price of their houses/land being affected which again comes under the category of the opportunity cost of land. This value is calculated along with the other boundaries. There may also be other costs relating to the livelihood of certain people being affected such as shopkeepers but that does not form a major part of the costs and is thus not considered. The eastern boundary hardly has any human habitation within the NDZ. This 2 km corridor served as a green belt that was used by the terrestrial birds for nesting. However, at present, the length of this green area is just 28 meters.

Major construction took place here in 2008 which destroyed these natural lungs. This was the Rashtriya Dalit Prerna Sthal and Green Garden situated at just 50 meters from the boundary. A total of 6,186 trees were cut for these 82.5 acres establishment which was constructed at a cost of almost ₹ 685 crores. Now, the opportunity cost of not allowing this structure to be there in proximity to the sanctuary would be the tourism revenue which will be foregone. The assessment of the true worth of this place would entail estimating the present value of this revenue stream by discounting future incomes over a valid period.

Several case studies have been mentioned in a book authored by Croitoru and Sarraf (2010) relating to the costs of environmental degradation. One such study includes the estimation of the incomes lost from tourism due to an oil spill at the Byblos World Heritage Site. The present value calculation, in this case, assumes 25 years for discounting the cash flows. Also, since we are discounting future incomes, the returns after a time of 25 or 30 years become insignificant (Hindriks and Myles 2013).

Another important component is the discount rate to be chosen. Generally, it is the rate of return that the investors expect or the cost of borrowing money. In this case, the investor is the government that has constructed this tourist spot. Therefore, the interest rate on government

securities can be used as the discount rate. This rate is found to be around 7% for the 24- and 26-years government bonds. It is often regarded as the private rate of discount. However, the social discount rate is something that cannot be ignored. This rate is seen as an improvement over the private discount rate because it also includes the impatience of the society, the growth rate of consumption, and the effect of uncertainty on the economy. A report by NITI Aayog recommends this rate to be around 8% for appraisal of economic projects. Hence, we calculate the present value of the revenue stream forgone at the base rate of 8% for 25 years.

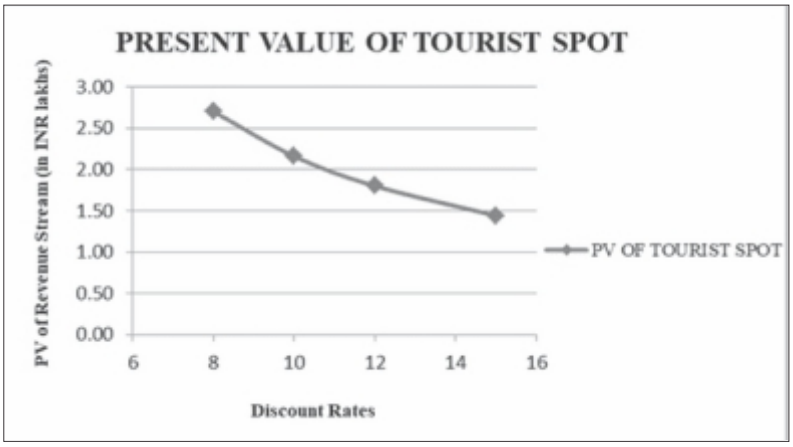
The number of tourists for this place averages around 12,000 per month. Taking this figure forward for 25 years and multiplying it by the ticket fare of INR 15; we get the revenue for one year. The present value is calculated using the standard formula represented by equation below.

$$\text{Present Value of the Revenue Stream} = \sum_{n=1}^{25} \frac{CF_n}{(1+r)^n}$$

where 'CF_n' is the cash flows received till period n and 'r' is the annual discount rate.

The present value of the revenue foregone from tourism is estimated to be INR 2, 70,000 or 0.02 crores in this case. The detailed calculation for the present value can be found in Annexure A. As seen from Figure 7 below, the present value declines with an increase in the discount rate. This is because as interest rates increase, less amount of money must be kept aside for earning a specified amount in the future.

Figure 7: Present Value of the Tourism Revenue



Another vital aspect to be considered here is the capital cost incurred in constructing this massive tourist spot which is INR 685 crores. This can be regarded as a sunk cost which cannot be recovered. It is apt to include this figure also in our opportunity cost calculation as this amount could be invested somewhere else at the time of construction. However, it must be in terms of the

present scenario that is inflation should be accounted for. The rate of inflation from 2010 (the year when construction ended) to 2020 has been around 97%. Overall, the opportunity cost of this foregone fixed cost comes out to be around INR 1,350 crores. Thus, the total opportunity cost for the Rashtriya Dalit Prerna Sthal and Green Garden comes out to be INR 1,350.02 crores. The southern boundary is also devoid of any habitation within a 100-meter distance.

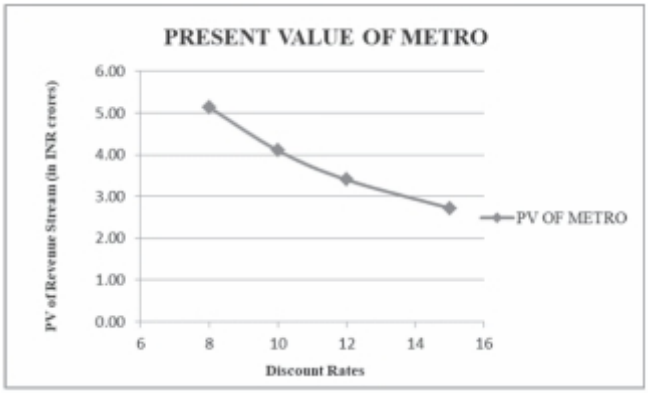
Yet, a major development that took place here in 2014 was the construction of the Kalindi Kunj- Botanical Garden metro corridor. This 3 km long elevated corridor, though at 105 m from the southern boundary, can be seen as being harmful to the avifauna. The environmental impact assessment carried out for this project also outlines this possibility. The EIA report states the potential of migratory birds being hit and thus their migratory route being endangered. There is also mention of the continuous noise pollution which interferes with the breeding of birds. Moreover, the bright lights used at the station are listed down as a deterrent which should be replaced with blue lights during the night as they have a shorter wavelength and the least adverse effect on the migratory birds. Calculating the opportunity cost for this INR 874 crores project entails finding out the income forgone if this metro service is stopped. Apart from the enormous social cost of curbing a mode of transport for the people, there is also a huge loss in the form of no future revenue stream. Here also the role of discount rate and time frame is crucial. Similar studies carried out on the metro in other cities assume a time of 30 years from the commencement of its operations. Hence, the opportunity cost calculation here is done for 30 years and using the same 8% discount rate mentioned earlier. Equation below corresponds with the same formula as equation 3 but replaces 'n' by 30 years.

$$\text{Present Value of the Revenue Stream} = \sum_{n=1}^{30} \frac{CF_n}{(1+r)^n}$$

where 'CF_n' is the cash flows received till period n and 'r' is the annual discount rate.

The present value found in this case is around INR 5.14 crores which also declines as we increase the discount rate as portrayed by the figure below. The detailed calculation for the present value can be found in Annexure B.

Figure 8: Present Value of the Revenue of Metro



The fixed cost or the investment cost of metro is again of crucial importance here. The amount of INR 874 crores must be corrected for inflation and added to the opportunity cost component. The inflation rate from 2017 to 2020 is approximately 20%. This amounts to a sunk cost of INR 1,048 crores. The total opportunity cost of stopping this metro service is estimated to be INR 1,053.14 crores.

Opportunity Cost of Land: A crucial element of this opportunity cost calculation is the value of the land which will get affected due to the development restrictions. Taking the market price of land as an estimate of the net present value forgone because of restricting development at a particular site seems feasible.

For this, the area of land falling within 100-meters from each boundary of the sanctuary was calculated by using the GIS techniques as before. The area was then multiplied by the circle rate of the nearest colony/sector to arrive at the total value of the land. The circle rate, instead of the market price, is used to get a fair and transparent idea of the land value.

The real estate market is highly opaque and thus the market price varies with each transaction. The circle rate is the minimum value set by the government on property transactions to avoid market speculations. In most cases, the market price is higher than the circle rate.

Therefore, our estimate of the total value of the land can be seen as a minimum benchmark with the market value being higher. Equation below depicts the formula used for arriving at the opportunity cost of land.

The opportunity cost of land = Value of the land situated in the NDZ

= (Area of land falling in the no-development zone) * (Circle rate of adjacent sector/colony in which the land is placed)

Table 2 shows the opportunity cost of the land calculated across the four boundaries. We can see from the table below that the total value of land in the 127 acres of the no development zone turns out to be a sprawling INR 2,789 crores with the highest value being for the densely populated western boundary.

The reason behind this figure is the high prices of land in Noida. This estimate of the opportunity cost of land represents the income that will be foregone by restricting future use of this land. This means that a total of INR 2,789 crores of value will not be realized by the development authorities if a NDZ is established.

Table 2: Market Value of Land in the NDZ

Boundary	Area of land in NDZ (sq. m)	Closest Sector/Colony	Circle rate of land (INR/ sq. m)	Total Value of land (INR)
A	B	C	D	E = (B*D)
Northern	60,000	15 A	40,000	(2,65,087*40,000) = 10.60 billion
Eastern	2,05,087	15 A and 16 B	40,000	
Southern	31,538	94 A	1,03,000	3.24 billion
Western	23,68,060 sq. ft.	Abul Fazal Enclave	5,934/sq. foot	14.05 billion
TOTAL	**5,16,625 sq. m or 127 acres**			**27.89 billion approximately which is equal to INR 2,789 crores**

4 CONCLUSION

This study aimed to identify and estimate the costs involved in biodiversity restoration for the Okhla Bird Sanctuary. The crux of the research emphasized the costs that arise because of restricting development activities in the vicinity of our study area. The total opportunity cost figure is calculated to be approximately INR 5,192 crores. This represents the income foregone in restoring the biodiversity of the sanctuary. The major part of this cost is the market value of land as property prices are very high in Noida. The other part is the revenue foregone from our two constituents - the tourist garden and the metro corridor.

Although the opportunity costs of erasing these two constructions are less vis-à-vis the opportunity cost of land, there is a huge political and social significance attached to them respectively which should not be overlooked.

The above estimate of opportunity cost can be compared to conservation estimates of some other studies to assess the accuracy of our calculations. A study done by Naidoo and Adamowicz (2005) has calculated the opportunity costs of conserving the avian biodiversity in an African Forest Reserve comprising of 143 bird species. The authors estimate a cost of $114 per hectare at 2001 prices. Converting these estimates into INR for the 302 species in the Okhla Bird Sanctuary, we reach an estimate of INR 5,561 crores at 2020 prices for a total of 450 hectares of land (400 hectares of the sanctuary and the 50 hectares of our NDZ). The reason for the difference between the two estimates could be the higher values of the foregone income of the farmers in the African Forest Reserve in terms of the market value of the crops

sold. It could also be due to more endangered or vulnerable species located there which may command a greater value.

Referring to the study by Batie and Mabbs-Zeno (1985), we can compare our estimate of the opportunity cost of land with their estimate of the development value of converting the wetlands into housing lots. The total opportunity cost found by them of conserving the coastal wetlands was around $31 million at 1976 prices for 58 acres of land. Correcting for inflation and considering the purchasing power parity, this amounts to INR 2,400 crores at 2020 prices for 127 acres of our NDZ. On the other hand, our estimate of the opportunity cost of land (127 acres) is around INR 2,700 crores. This disparity can be attributed to the inclusion of only the value of the houses that is the developed land in the estimates of Batie and Mabbs-Zeno (1985), thus leaving out the undeveloped land which is considered in our study.

7.1 Research Gaps

Certain assumptions are taken in reaching the results of our analysis which may be viewed as limitations of our study due to the lack of data. Concerning the opportunity costs of restoration, certain costs relating to the livelihood of the people being affected are not estimated. These include the shopkeepers that might be operating in the no development zone, the caretakers or gardeners at the tourist spot, and the employees working at the metro station. For this last category, the employees may be transferred to some other metro station thus leading to no change in the overall opportunity cost. The other two categories are assumed to lead minuscule estimates as compared to the other components which are included.

7.2 Policy Implications

These opportunity costs can be incorporated into the decision-making process of designing a payment contract wherein the owners affected by the restoration can be compensated. The society will benefit more if these payments are equivalent to the opportunity costs of restoration and not higher. The people residing in the western boundary along the sanctuary can be viewed as the affected population as their houses will be displaced due to the restrictions. Thus, these individuals will need to be compensated for their loss. For an optimal decision, the payments given to them should be equal to their opportunity cost which is INR 1,400 crores. Direct compensation payments are seen are more cost-effective and requiring less institutional complexity than the indirect approaches of payment.

Also, since the other development activities have already taken place, the cost estimates be utilized for future decisions. For any industrial/commercial/residential construction in the future, these estimates can be matched with the benefits provided by the Okhla Bird Sanctuary. The monetary estimates of the ecosystem services provided by the wetland (provisioning, regulating, recreational, et cetera) could be compared with the opportunity cost of the undeveloped land that is the market value of the fallow land near the sanctuary.

Preserving Similar Sites

Last but by no means least; a very important aspect is the preservation of other stoppage sites of migratory birds. These birds do not restrict themselves to just one place as more than one site is part of their migratory route. For example, birds from the Okhla Bird Sanctuary travel further to the Dhanauri wetlands in Greater Noida. As of now, this wetland is untouched by any kind of anthropogenic pressure. However, there is a proposal being deliberated about constructing a road right through the centre of the wetlands. To protect the environment of this place, a timely decision regarding demarcating eco-sensitive zones should be taken here. The opposite was done in the case of our study area where political powers kept on delaying this decision due to their vested interests. Therefore, to conserve biodiversity in the longer run, it is crucial to identify and conserve such zones along the migratory route of the avifauna.

Also, conflicts between conservation and development are seen across India. Few examples include the Pulicat Bird Sanctuary in Tamil Nadu where the MoEFCC has reduced the boundary of the eco-sensitive zone from 10 km to 2 km to enable building of ports, Tungareshwar Wildlife Sanctuary in Maharashtra where again industrial activities have been constrained by announcing a buffer of 67 sq. km around the sanctuary. In densely populated areas like Guindy National Park in Chennai and Sanjay Gandhi National Park in Mumbai, the requirements of eco-sensitive zones mean regulation rather than prohibition of development activities. India has 102 national parks and 515 wildlife sanctuaries. Making explicit the importance of biodiversity in these areas along with the costs of restoring them will act as a crucial source of information for the policymakers to make informed decisions and achieve a balance between the short-term economic gains and long-term benefits of biodiversity conservation.

References

[1] Adams, V. M., Pressey, R. L., & Naidoo, R. (2010). Opportunity costs: who really pays for conservation? *Biological Conservation 143*, 439-448. doi.org/10.1016/j.biocon.2009.11.011

[2] Batie, S. S. & Mabbs-Zeno C. C. (1985). Opportunity costs of preserving coastal wetlands: A case study of a recreational housing development. *Land Economics 61*,1-9. doi.org/10.2307/3146134

[3] Chomitz, K. M., Alger K., Thomas T. S., Orlando H. & Nova P. V. (2005). Opportunity costs of conservation in a biodiversity hotspot: the case of southern Bahia. *Environment and Development Economics 10*, 293-312. doi:10.1017/S1355770X05002081

[4] Croitoru, L. and Sarraf M. (2010). *The cost of environmental degradation: Case studies from the Middle East and North Africa.* World Bank Publications

[5] Ferraro, P. J. (2011). The future of payments for environmental services. *Conservation*

Biology 25, 1134-1138. https://doi.org/10.1111/j.1523-1739.2011.01791.x

[6] Ferraro, P. J., Naidoo R., Balmford A., Polasky S., Ricketts T.H. & Rouget M. (2006). Integrating economic costs into conservation planning. *Trends in Ecology & Evolution 21*, 681-687. https://doi.org/10.1016/j.tree.2006.10.003

[7] Gagné, S. A., and Lenore F. (2010). The trade-off between housing density and sprawl area: minimizing impacts to forest breeding birds. *Basic and Applied Ecology 11*, no. 8: 723-733. doi:10.1016/j.baae.2010.09.001

[8] Gowdy, J. M. (1997). The value of biodiversity: markets, society, and ecosystems. *Land economics 73*, 25-41. doi:10.2307/3147075

[9] Hindriks, J. and Gareth D. Myles. (2013). *Intermediate public economics*. Cambridge: MIT Press

[10] Liang, C. & Li X. (2012). The ecological sensitivity evaluation in Yellow River Delta National Natural Reserve. *CLEAN–Soil, Air, Water 40*, 1197-1207. https://doi.org/10.1002/clen.201200051

[11] Naidoo, R. & Ricketts T. H. (2006). Mapping the economic costs and benefits of conservation. *PLOS BIOLOGY 4*, 2153-2164. https://doi.org/10.1371/journal.pbio.0040360

[12] Naidoo, R. & Adamowicz W.L. (2005). Economic benefits of biodiversity exceed costs of conservation at an African rainforest reserve. *Proceedings of the National Academy of Sciences 102*, 16712-16716. https://doi.org/10.1073/pnas.0508036102

[13] Parsons, G. R., and Yangru W. (1991.) The opportunity cost of coastal land-use controls: An empirical analysis. *Land Economics 67*, 308-316. https://doi.org/10.2307/3146426

[14] Prakash, V., Saran S., & Talukdar G. (2018). Delineating Eco-sensitive zones using geospatial methods – A test case of Jhilmil Jheel Conservation Reserve. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences 4*,459-466. doi:10.5194/isprs-annals-IV-5-459-2018

[15] Urfi, A.J. (2003). The birds of Okhla barrage bird sanctuary, Delhi, India. *Forktail 19*: 39-50. http://orientalbirdclub.org/wp-content/uploads/2012/09/ Urfi-Okhla.pdf

Annexure A

Present Value Calculation for the Rashtriya Dalit Prerna Sthal and Green Garden

Table A1 below depicts the statistics estimated for the present value calculation. The average number of tourists i.e. 12,000 per month is extrapolated to the year 2036 staring with 2020. The annual revenue of INR 21, 60,000 is then discounted for 30 years at 8% discount rate.

Table A1: Revenue Stream for 25 years of the Rashtriya Dalit Prerna Sthal and Green Garden

YEAR	NUMBER OF TOURISTS	TICKET PRICE (INR)	REVENUE (INR)
2011	1,44,000	15	21,60,000
2012	1,44,000	15	21,60,000
2013	1,44,000	15	21,60,000
2014	1,44,000	15	21,60,000
2015	1,44,000	15	21,60,000
2016	1,44,000	15	21,60,000
2017	1,44,000	15	21,60,000
2018	1,44,000	15	21,60,000
2019	1,44,000	15	21,60,000
2020	**1,44,000**	**15**	**21,60,000**
2021	1,44,000	15	21,60,000
2022	1,44,000	15	21,60,000
2023	1,44,000	15	21,60,000
2024	1,44,000	15	21,60,000
2025	1,44,000	15	21,60,000
2026	1,44,000	15	21,60,000
2027	1,44,000	15	21,60,000
2028	1,44,000	15	21,60,000
2029	1,44,000	15	21,60,000
2030	1,44,000	15	21,60,000
2031	1,44,000	15	21,60,000
2032	1,44,000	15	21,60,000
2033	1,44,000	15	21,60,000
2034	1,44,000	15	21,60,000
2035	1,44,000	15	21,60,000
2036	1,44,000	15	21,60,000

Annexure B

Present Value Calculation for the Kalindi Kunj – Botanical Garden Metro Corridor

In case of the metro, the numbers of the daily passengers were estimated by the EIA report only for the years 2016, 2021, 2026 and 2031. Using online tools, the per year growth rates were calculated to fill in the missing values between these years. The slope and intercept of the values till 2031 were found out using Excel and utilized to predict the future values. Finally, the total revenue was calculated for each year by multiplying annual number of passengers with the fare. The fare was increased by 7% every year based on the recommendation of the Fare Fixation Committee.

Table A2: Revenue Stream for 30 years of the metro corridor

YEAR	NUMBER OF PASSENGERS (PER DAY)	FARE (INR)	ANNUAL NUMBER OF PASSENGERS	REVENUE (INR)
2016				
2017	48,292		1,76,26,580	
2018	50,639		1,84,83,235	
2019	53,100		1,93,81,500	
2020	55,680	20	2,03,23,200	40,64,64,000
2021	58,387	21	2,13,11,255	44,75,36,355
2022	60,348	22	2,20,27,020	48,45,94,440
2023	62,376	24	2,27,67,240	54,64,13,760
2024	64,472	26	2,35,32,280	61,18,39,280
2025	66,638	28	2,43,22,870	68,10,40,360
2026	68,877	30	2,51,40,105	75,42,03,150
2027	70,840	32	2,58,56,600	82,74,11,200
2028	72,859	34	2,65,93,535	90,41,80,190
2029	74,936	36	2,73,51,640	98,46,59,040
2030	77,071	39	2,81,30,915	1,09,71,05,685
2031	79,268	42	2,89,32,820	1,21,51,78,440
2032	81,827	45	2,98,66,855	1,34,40,08,475
2033	84,029	48	3,06,70,585	1,47,21,88,080
2034	86,230	51	3,14,73,950	1,605,1,71,450

2035	88,432	55	3,22,77,680	1,77,52,72,400
2036	90,633	59	3,30,81,045	1,95,17,81,655
2037	92,835	63	3,38,84,775	2,13,47,40,825
2038	95,036	67	3,46,88,140	2,32,41,05,380
2039	97,237	72	3,54,91,505	2,55,53,88,360
2040	99,439	77	3,62,95,235	2,79,47,33,095
2041	1,01,640	82	3,70,98,600	3,04,20,85,200
2042	1,03,842	88	3,79,02,330	3,33,54,05,040
2043	1,06,043	94	3,87,05,695	3,63,83,35,330
2044	1,08,245	101	3,95,09,425	3,99,04,51,925
2045	1,10,446	108	4,03,12,790	4,35,37,81,320
2046	1,12,648	116	4,11,16,520	4,76,95,16,320