A HEDONIC PRICING TECHNIQUE TO VALUATION OF BIODIVERSITY IN MINING AREA IN GOA

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Abstract: *Goa's exploitation of its mining resources has impacted biodiversity of adjoining areas. This paper maps the mining and adjoining areas including households and uses a hedonic pricing approach to study impacts through loss of biodiversity in those areas. Bicholim and Valpoi were the areas studied. The price of land in India being set by government as guidance value provides a bench mark for the market price that is over and above this guidance value, and there are no official records of the same. This information can be obtained from real-estate agents or from the persons involved in the transaction. The author approached the house owners themselves. The perception of protected area and actual vegetation were divorced from reality as data, observation through mapping and analysis thereon reflected.*

Key Words: *Bio Diversity, Mining, Hedonic pricing, Geographical Information System, Habitats*

INTRODUCTION

Located on the West coast and spanning 7000 sq. km, Goa is India's smallest state by area. Although it is famous for its beaches and its coastline, nearly 38% of its area is forest. These forests are a part of the Western Ghats – a UNESCO-certified biodiversity hotspot of the world. Biodiversity is referred to as 'the degree of variation in life' by UNEP though the definition of biodiversity is a matter of complex discourse. Biodiversity refers to all the biotic elements of the area. Biodiversity hotspots are specific regions where the biodiversity in the region is both extensive and unique. The uniqueness of species (endemism) means a significant portion of the species are found nowhere else on earth. Located close to the tropics, the Western Ghats have high levels of biodiversity –over 5000 species of flowering plants, 138 mammal species and 508 bird species (Myers et. al., 2000).

Goa has significant deposits of manganese, bauxite and iron ore. The then Portuguese government handed 700 'mining concessions' to allow people to mine the area. Post liberation, the Government of India cancelled these concessions and provided 'mining leases' under the Indian mining and environmental regulation Acts in 1987. Despite these measures, the mining industry has grown exponentially – from less than 5 mt in the 1960's to more than nearly 60 mt in 2011. An inquiry into illegal mining by the Shah commission a Supreme court interim ban on all extraction occurred. In April 2014, the ban was lifted and an annual cap of 20 mt for ore extraction has been placed (Goa foundation - *Sweet Land of Mine*, 2009).

Valuation of biodiversity

The transition from traditional subsistence establishments into large-scale market economies has greatly altered the perception of value of natural resources. Traditional forest-dwelling communities view natural resource as a carefully managed endowment utility (usually) with community-driven regulation. Market economies seek to add monetary value to natural resources. The change bestows a severe negative externality in the inherent undervaluing of natural resources by ignoring the non-market benefits offered by them. Natural resource economics attempts to account for these 'non-use-values' by using several techniques, one of which is hedonic pricing. Hedonic Pricing (HP) in the context of natural resource valuation has been used to value urban forests, tourist destinations, beaches, agriculture, and air quality and landmass degradation. There are only a few cases where hedonic pricing has been applied to assess mining impacts. The reason for this is the absence of a competitive real-estate market in and around mines due to possible threat of severe health hazards. However, mining is a common feature in India and especially so in the state of Goa where mining is a major source of revenue. Land is a scare resource here and consequently, the health hazards notwithstanding, people are driven by economic incentives only to reside in areas close to the mines. Field survey by the authors has corroborated this claim. An added variable in the equation is Goa being a part of a UNESCO-certified biodiversity hotspot. This means the damages of mining – direct and secondary – have a big impact on the neighboring bio diversity.

An overview of Hedonic Pricing

The Hedonic-price methodology was developed by Rosen (1974). It addresses decision making factors and joint-ness of consumption of public goods by using revealed willingness-to-pay (WTP) statistics of consumers. It is a technique that is based on the proposition that the price of land in an ideal market is set by the superposition of benefits accrued from different attributes or characteristics. This way, the respondent's bias is avoided and benefits are disaggregated. There is a functional relationship between price and various characteristics, with the characteristics ranging from real-estate characteristics like floor space, number of bathrooms, etc. to landscape parameters like distance from forest area, altitude of the region, etc.

GIS or Geographic Information System is increasingly becoming an indispensable tool in landscape studies. In the context of Hedonic pricing, several studies have used GIS-based variables in the functional relationship with land prices. The focus is of effects of different landscape parameters on the prices.

Remote Sensing and GIS

Remote sensing has proved to be an invaluable tool in biodiversity valuation studies. Primarily used to supplement field-based hypothesis, it is increasingly being used directly, to glean information of satellite imagery and use them for analysis. Remote sensing refers to the acquisition of spatial imagery data from satellites, and Geographical Information System (GIS) is the computer system that designs, stores, analysis and manages this data. Remote sensing analysis usually involves analysis raw data, processing the images and obtaining reliable information. Using reflectance values, a good estimate of the nature of land use can be ascertained. Time series data of this form can be used to find land-use changes (Yadav et. al., 2012) in areas of significant biodiversity. While differentiating between different land-use patterns (viz. agriculture, dense forests, open forests, water bodies, etc.) is relatively error prone, attempts to distinguish species of trees from this spatial data is highly challenging. Several attempts to find a unique spectral image for a particular species have been made and some broad patterns have emerged but our technology today is not in a position to find out such special identification (Environmental heterogeneity) to significant accuracy (Rocchini et. al., 2010). Also, such spatio-temportal studies are highly specific and thus the consequent policy decisions are not scalable. The suggestion is to have self-organizing local policy formulation and implementation (Nagendra and Ostrom).

With such specificity and cumbersome methodologies, purely remote sensing-based studies stand on shakier ground than studies that have a combination of 'ground-truthed' data/hypothesis. Studies prefer GIS-analysis on *existing* data. In GIS terminology, studies favor working with vectors (readymade polygons/lines/points such as Google maps) rather than with rasters (direct satellite images).

LITERATURE REVIEW

Hedonic pricing and GIS

Aurelia (2003) considers the case of Castellon in Spain by testing the veracity of three environmental variables, of existence of garden view, distance from nearest green area and its size, apart from conventional characteristics variable. A negative relationship was found to exist between selling price and distance to urban green area. A linear model with OLS was employed, along with a double-log model to check elasticity of price with respect to explanatory variables.

Saphores and Li (2012) value single houses in Los Angeles, USA by noting the influence of urban trees, irrigated grass and non-irrigated areas on land prices in the area. Several area-specific conclusions on people's choices were statistically obtained.

In Snyder et. al. (2007), location factors and in-situ factors of undeveloped forest land in Minnesota, USA was tested against market price. A linear model was followed, as it is best suited for unobserved variables. Road access, financial arrangement, water frontage and future intensions had significant positive impact on price while agricultural land and lack of real-estate agent had a negative influence. Timber volume on the land parcel had little effect.

Anthon, Thorsen and Helles (2005) studied the impact of urban fringe afforestation projects in areas of little previous green cover. The hedonic pricing approach revealed an increase in prices at the time of afforestation with prices higher for land parcels that are closer to the new forest.

The 1996 study by Tyravainen examines the non-consumptive use values obtained by urban forests in North Carelia, Finland. A linear functional relationship was assumed. The proportion of forested area and the proximity to watercourses/wooded areas had a positive influence on apartment price, but these responses were small in relative magnitude.

Hunt et. al. (2005) mapped the effect of forest harvesting on the tourism benefits, specifically fly-in fishing sites. They used a spatial autoregressive model (a semi-log model) that differs from the linear model by a spatially lagged variable, arising from a spatial error. They found that the extraction had weakly negative effect on the tourism benefits, and found that the refined model (non-zero spatially lagged variable) varies the magnitude of marginal benefits.

Hedonic pricing has a wide range of applications even within the sphere of land-use studies. Apart from urban forests as mentioned above, they can be used to value beaches (Gopalakrishnan et. al., 2010) and air quality (Anselin and Le Gallo, 2006). The latter uses the maximum likelihood and general method of moments technique along with a spatially lagged variable, while the former employs modifications to regular OLS.

Other applications include agriculture (Goeffe, 1999) and landmass degradation in an agricultural context (Paliwal et. al., 1999). The latter presents one of the few Hedonic pricing studies from India. Paliwalet. al. judge the quality of the landmass (and hence the hypothesized degradation) based on three factors – Suitability, Operability and Comparability. Fuzzy logic is employed and regression is done for fuzzy numbers generated. A marked conversion of agricultural to urban (hence loss) was observed.

Geoghegan, Wainger and Bockstael (1997) used GIS-based hedonic analysis of spatial landscape indices. Apart from using the usual residential values, of in-situ and bio-geographical factors, they included indices that accounted for patterns of surrounding land use. They map the diversity, fragmentation, fractal dimension, edge length between land uses, among others as spatial variables. A linear model in a natural log from is utilized and coefficients are derived from OLS estimation. The studies found that the land-use in surrounding parcels affected the price of the parcel concerned, and the effect of landscape features is highly dependent on the nature of the parcel – whether it belongs to a highly developed, suburban or relatively rural area.

Similar studies have been done in China (Lee and Li, 2008) and France (Cavialhes et. al., 2009) where the spatial variables have been given extra preference over the traditional landscape variables.

Damigos and Kaliampakos (2003) assess the benefits from alternate land-use of abandoned granite quarry in Greece using Contingency Valuation (CV), Hedonic Pricing (HP) and Travel Cost Method (TC). The Aggregates from each of these methods are then compared; the total willingness to pay (WTP) broadly straddled the reclamation cost. The HP technique involved here follows the fuzzy Delphi method, a group judgement technique first introduced by Kaufmann and Gupta (1988). It is a combination of fuzzy logic that uses non-definite numbers and the Delphi method. The Delphi method in the context of hedonic pricing is employed by asking a group of experts to fill in a questionnaire with probable prices, and revise them on a second iteration by using statistically averaged estimates. HP in this manner revealed a premium of 15 - 36% in the reclaimed quarry zone. The paper emphasised the need for the application of non-use value estimation in the mining context.

In Kuminoff et. al. (2010), the authors test the effect of omitted variables on the final result in hedonic pricing models using a meta-analysis of a variety of studies. They conclude that moving from the proverbial 'Occam's Razor' approach to less simplified and more general formulations will provide better results. They also elaborate on the susceptibility to change in time function. Monte-Carlo simulations are utilized to perform these model experiments. With respect to this study, it highlights the importance of obtaining temporally specific land-prices, and the importance of spatial support to field-collected data.

Remote sensing and GIS for biodiversity studies

Rocchini, Balkenhol, et. al. (2010) provides a review paper on remotely sensed spectral heterogeneity – variation in visual spectra from the images – and their viability of usage as a proxy for species identification. A major problem with spectral heterogeneity as a proxy for diversity is the inability to account for uniqueness or ecological importance of different habitats.

Yadav, P.K., Kapoor M. and Sarma K. (2012) provide a case study for mapping land cover changes from India, specifically the Nagzira-Navegaon corridor in Central India. They used Landsat imagery for the three time periods of 1990, 1999 and 2009, classified the land into dense forest, open forest, water body and non-forest for both the sets and found their changes, concentrating on the corridor between two protected habitats. It was found that from 1990 to 1999, a significant part of the forest changed from dense to open forest, probably highlighting insufficient protection. From 1999 to 2009, an opposite trend is seen.

The corridor itself was most prone to conversion to non-forest are at the location of roads and other linear projects.

Roy P.S. and Sharma S. (2007) present another case study for such remote sensing-GIS applications from the Central Himalayas. They mapped the fragmentation of forest landscapes within their study area of 5167 sq. km. and found 41% of that forest was fragmented. They also checked it at various scales, from 75x75m to 575mx575m. Studies have found that at least 40m changes are felt in the microclimate from edge effects, thereby rendering literally the whole sample area susceptible to these changes. While the size of fragmentation is very small, the scale of this is alarming throughout the Himalayan region as it can all be classified as highly fragmented.

Menon, S. and Bawa K.S. (1997) perform several analyses – modeling deforestation, biomass estimation, land-use change, fragmentation, and correlation with socioeconomic drivers of land use change. They study two regions of the Western Ghats – the Biligiri Rangan Hills and Agastyamalai region.

Nagendra, H. and Ostrom E. (2011) perform a meta-analysis of forest-density changes as monitored in sample plots from 53 case studies. They find that while tree changes monitored by the users strongly correlated with randomly distributed forest plots, shrub/sapling changes were less strong. Also, changes are difficult to monitor from field data, and thus local solutions are recommended for monitoring habitats.

Kotha M. and Kunte P.D. (2013) studied Goa's Land-cover changes using similar techniques as Roy and Sharma. They looked at 4 different land forms – settlement, vegetation, open land and water bodies – and found their temporal distribution each decade, over 4 decades. They used Landsat imagery, used GIS to vectorize this data and found the net areas and changes in the same. Other image pre-processing techniques were also used. They found that in the first decade change, the vegetation fell sharply and the settlement area increased considerably. In the subsequent decade, a slight increase in green cover despite a lower but increasing settlement area indicated some afforestation measures.

METHODOLOGY

Approach and field survey

The village of Bicholim and the village of Valpoi are taken as locations of study. Bicholim has long been the centre of mining activity in Goa and considered a mining centre. Valpoi is located at the foothills of the Chorla Ghat and has little or no mining activity in the area around it. Moreover, the forested areas around Valpoi are rich in biodiversity and present an interesting case of contrast with the locations in Bicholim.

The price of land in India is set by the government which sets the guidance value. The market value is over and above this guidance value, and there are no official records of the same. Thus, once could either obtain this information from real-estate agents or from the persons involved in the transaction. Due to paucity of contacts in the regions, the author approached the house owners themselves. However, after surveying 5 households, the variance of information collected, specifically land prices was too high to obtain any tangible information. The quoted values of land prices at the time of purchase varied from Rs.400/sq. ft. to Rs.3/sq. ft.! There was difficulty in communicating in English, many didn't remember the rates and/or had no access to official rates. Most importantly, people were sceptical about revealing information, especially since the issue of mining was sensitive with the Goan public divided in their opinion of the same, and the people near mines bearing the brunt of the economic burden from the mining ban.

Thus the methodology involved created a framework for this analysis with more reliable land prices obtained later. Therefore, the spatial attributes table – of distances from different land use variables from each household was obtained.

GIS analysis

Each Taluka in Goa is divided into villages, and the delimitation of these villages has been obtained from the village maps as a part of the 2021 Goa Regional Plan, accessed in the Goa Files website (goafiles.com, hosted by BITS-Pilani Goa Faculty, Mr. Solano and available for free). Bicholim and Sattari are the two Talukas, and Bicholim village and Valpoi villages are the two villages from the respective talukas that have been considered for this study.

The regional plan also specifies the different classification of land – as agricultural land, commercial land, mining area, protected area, etc., apart from roads, prominent locations, rivers, and also numbered plots.

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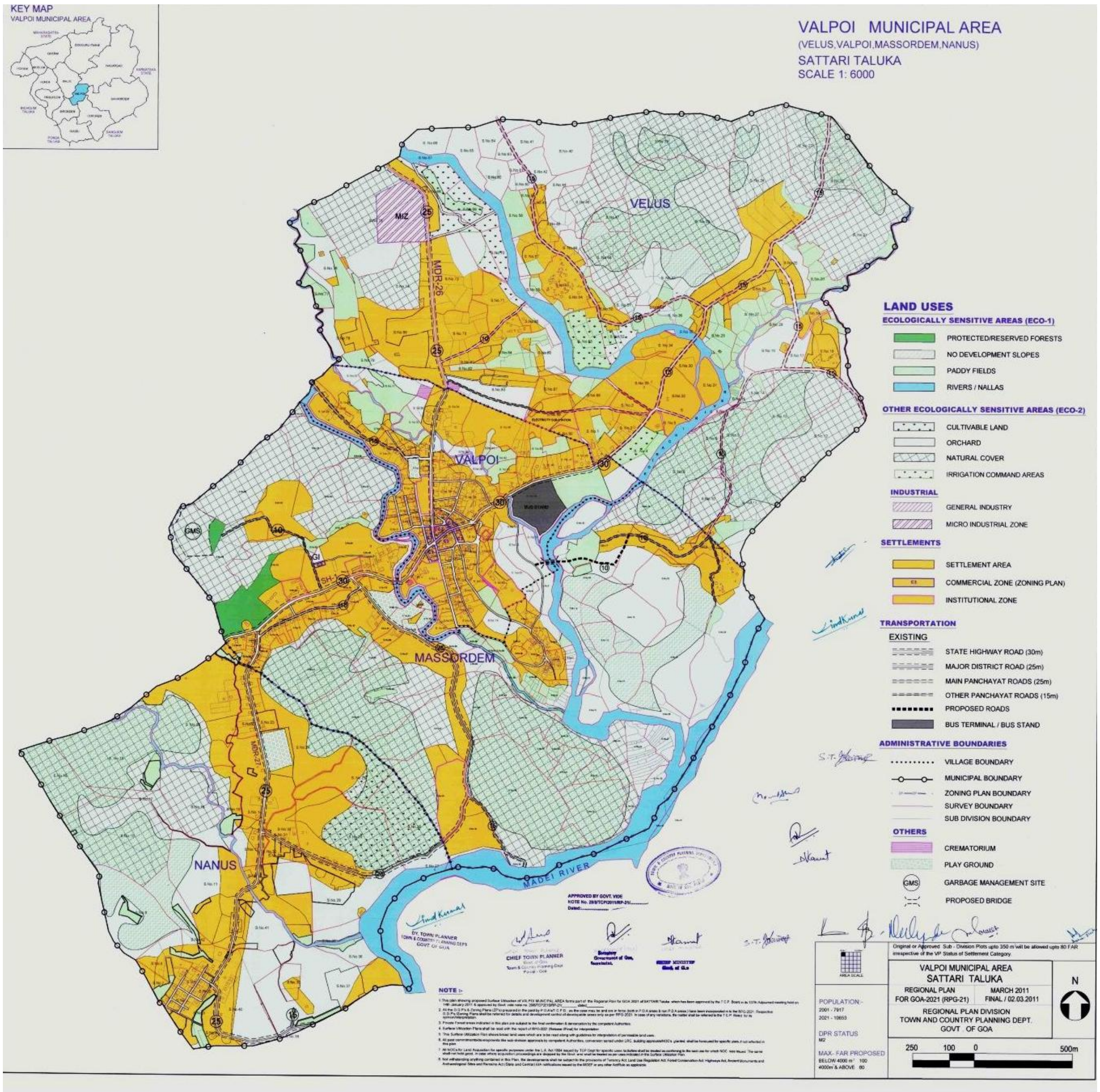
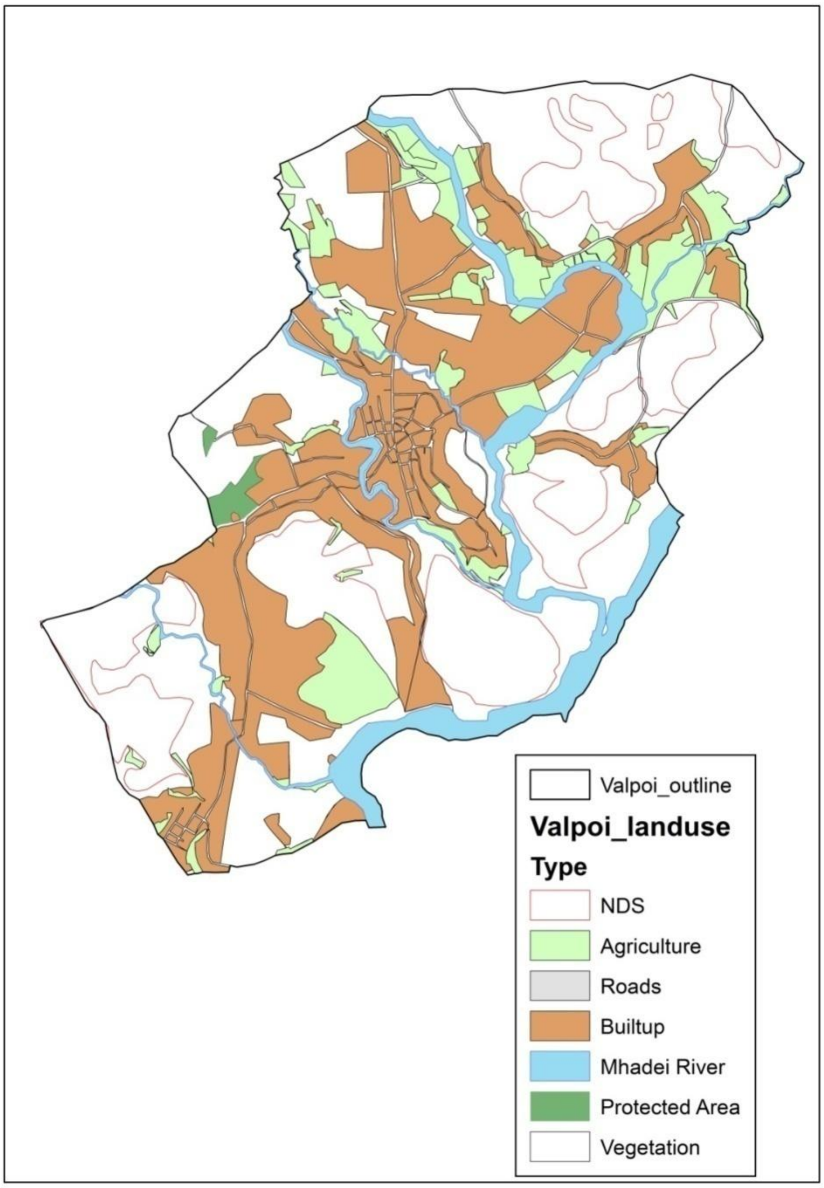


Fig1. VALPOI VILLAGE, SATTARI TALUKA (Source: goafiles.com)

All these landscape features were converted into a vector map of the same. Only the different land use types were found out. The vector image is shown below –

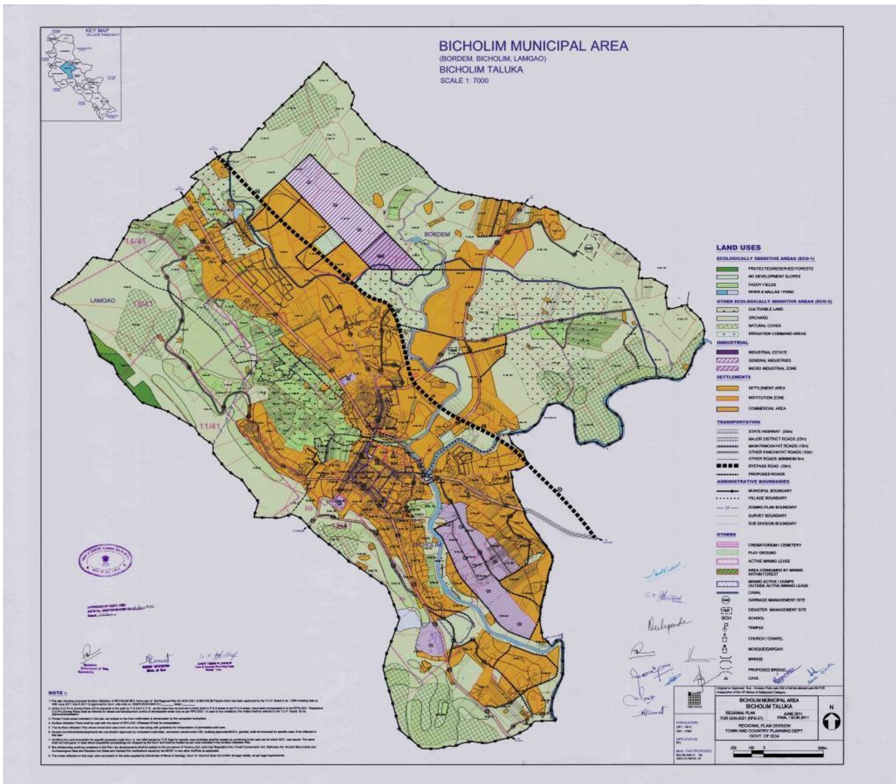


VALPOI MAP DETAILS*

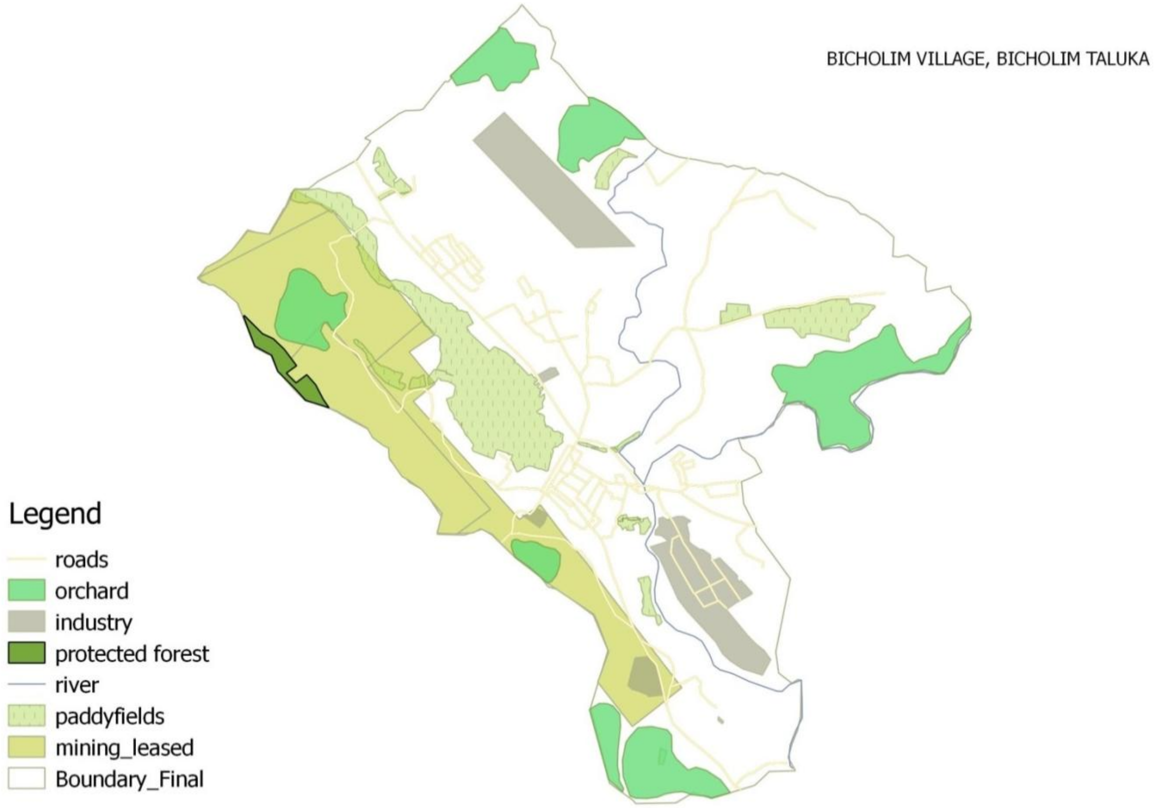
Type of Land-use	Area in km2	% of total area
Built up area	3.61338598	29.37335064
Roads	0.620898563	5.047307791
Vegetation	6.258476527	50.87539125
protected area	0.068695487	0.558428199
Non-Development Slopes	2.360105226	19.18538421
Mhadei River	0.889560068	7.231267275
Agriculture	1.265262191	10.28536397
Size of valpoi boundary	12.30157916	

* - Land-use overlap and hence do not add up to size of boundary

Similarly, the Bicholim village and the corresponding Bicholim vector image



Vector image

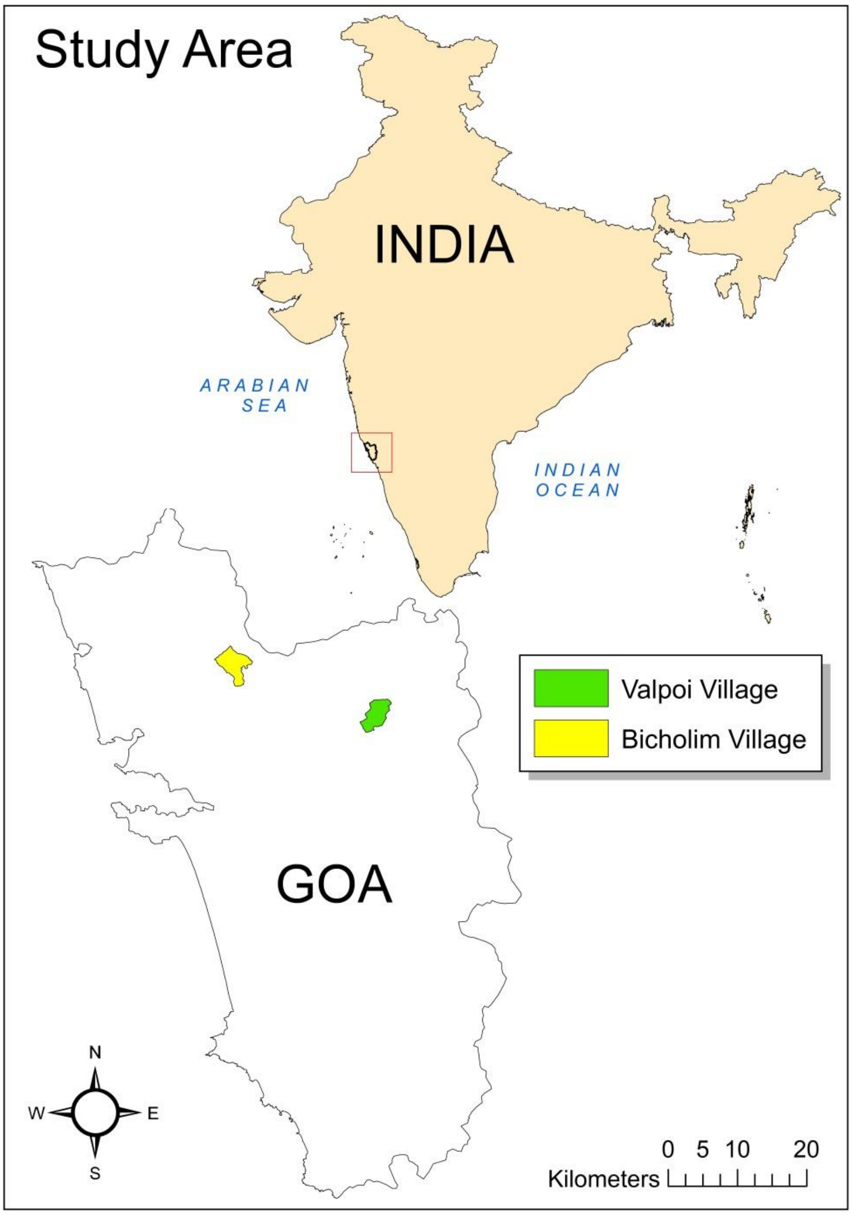


BICHOLIM MAP DETAILS*

Type of Land-use	Area in km2	% of total area
Area under mining lease	2.571741897	17.57581249
Industrial area	0.831651241	5.683675443
Vegetation	1.380255309	9.43294836
protected area	0.077588905	0.530258515
Non-Development Slopes	0.732408532	5.005430383
Built-up area	7.947848742	54.31723121
Agriculture	1.090784239	7.454643596

Size of Bicholim boundary 14.63227886

* - Land-use overlap and hence do not add up to size of boundary



RESULTS

Bicholim is a mining taluka but one would expect that the mining will stay far from the residential area. However, one can see that 17% of the village's area is under active mining lease, and the location of the mines is 124m from the nearest settlement. This indicates that in regions where the economic effects of mining are significant, the environmental and health diseconomies are neglected by the people concerned. This observation is also buttressed by the field survey where all people living very close to the mines in Lamgoa, Bicholim answered that there were negatives of mining but the positive impact it had on livelihoods were also significant.

One must also note that while 17% of the area is leased for mining, all area is not mined. Several agricultural areas lie within these leased areas, and so do forests, including protected areas. Even settlements can be found inside these areas, separated by a non-development slope region.

For the village of Valpoi, it is found that like Bicholim (50%) it too has a large built-up area (29%). But the amount of forested area (vegetation and non-development slopes) forms a significant 69%. The forested area in Bicholim (including vegetation, non-development slopes and protected area) include just 14.5% of the Bicholim area. A key difference is that 0.5% of this forest is protected while none of the forests in Valpoi (classified as vegetation and non-developmental slopes) is protected. In terms of agriculture, Valpoi has a little more area under agricultural cultivation than Bicholim, (10% and 7% respectively) but the corresponding built-area is significantly smaller.

In the field survey conducted, the land pieces was bought between 1975 and1992. The average household numbered 4.6, the average number of trees per plot was 17.5 trees, the average size of each plot was 675 sq. m. (approximately 120ft x 60 ft) and the average number of rooms was 3. All field correspondents reported a positive effect of mining on the livelihood people and all of them also reported a negative impact of mining on air quality. Health and water quality had either worsened or remained the same while mining seemed to have no effect on civic amenities, they felt.

The prices quoted varied from Rs.13 per sq m, to Rs.400 per sq. m, and the information was deemed unreliable for these numbered varied too much, and were counter intuitive – the price of plot 4 was reported as Rs.13/- when it was bought in 1983 but the price of patches bought in 1982 and 1975 – much before plot 4 – were priced Rs. 100 and Rs.400 respectively. Also, all these survey plots were from the same neighborhood of Lamgao, and hence the variability was difficult to not attribute to interviewee bias. Since the prices were also rounded to the nearest hundred (usually), it seemed like the residents had no exact memory of the prices thus heightening our margin of error.

The opinion of the interviewed residents was fairly uniform on the impacts of mining. All of them agreed that forests must be preserved for posterity (one them suggested controlled exploitation in the future) and believed that collection of non-timber forest produce (viz. amla, honey, etc.) should be allowed for local communities residing in protected areas. 4 out of 10 persons interviewed felt hunting should not be allowed however for the same forest-dwelling communities, and 3 out of 5 agreed that the tourism levels in biodiversity-rich areas were lower as compared to beaches and recommended increasing the efforts to improve their preference.

The awareness levels of the locals were quite high. All of them recognized the presence of amphibians, various types of insects, butterflies and reptiles in the area. They recognized mammals in the region and also mentioned habits of these mammals that were consistent with scientific studies. For instance, mongooses were reported by all those surveyed, and they were said to be active in the fringes of towns. Many reported presence of civet cats, and their habit of feeding on fruits and seeds at night was also reported. The presence of leopards in the forested areas was reported. A majority of those surveying the area found that biodiversity in general had increased since the mining ban of 2011, and reported that new bird species – not seen during the mining days – were being seen now.

Awareness about Goa's diversity was also seen. All of them underestimated the number of bird species in Goa, with all of them stating 50-150 species found in the state. However, Goa boasts an impressive 432 species of which 250 odd species are found throughout the year. All of them believed that biodiversity had decreased in the past decade and most of them felt that awareness levels had increased in the past decade. All of them had visited a wildlife sanctuary in their lifetime, most of them mentioning Bondla as among the places visited.

CONCLUSION

The issue of development, mining and biodiversity is complex and most studies demonstrate the need to deal with them using local rationale. Over the past decade, while needs and demands have increased manifold, awareness levels too have increased. That has been demonstrated by the survey which elucidates the negative impact of mining on health and environment, the feeling that while biodiversity has decreased in the past decade, awareness levels have increased, and that mining does provide tangible livelihood benefits to people.

One of the limitations is that a large chunk of the active mining leased area is 'not' mined, and there is agriculture, settlement and even protected areas in the region. This was not studied.

The perception of protected area and actual vegetation is also highly skewed from actual reality. For instance, in the map of Valpoi village, none of the nearly 70% vegetation was preserved, despite most of the village area being covered by natural vegetation while Bicholim on the other hand has a lot of built up area and they a small section is deemed 'protected area'. Studies have shown that protected habitats in the area require inviolate habitats with significant buffers – the idea of a buffer *inside* a protected area in the case of Bicholim is inconceivable.

REFERENCES

1. Aurelia Bengochea Morancho. 2003, 'A hedonic valuation of urban green areas'. *Landscape and Urban Planning,* vol. 66 pp. 35-41.
2. Saphores J. & Li W. 2012, 'Estimating the value of urban green areas: A hedonic pricing analysis of the single family housing market in Los Angeles, CA', *Landscape and Urban Planning,* vol. 104 pp. 373-387
3. Snyder S.A., Kilgore M.A., Hudson R. &Donnay J., 2008. 'Influence of purchaser perceptions and intentions on price for forest land parcels: A hedonic pricing approach', *Journal of Forest Economics*, vol. 14 pp. 47-72
4. Signe, Thorsen B. J.&Helles F. 2005, 'Urban-fringe afforestation projects and taxable hedonic values'. *Urban Forestry & Urban Greening*, vol. 3 pp. 79-91.
5. Hunt L., Boxall P., Englin J. &Haider W. 2005, 'Remote tourism and forest management: a spatial hedonic analysis', *Ecological Economics*, vol. 53 pp. 101-113.
6. SatyaGopalakrishnan, Martin D. Smith, Jordan M. Slott, A. Brad Murray. 2011, 'the value of disappearing beaches: A hedonic pricing model with endogenous beach width', *Journal of Environmental Economics and Management*, vol. 61 pp-297-310.

7. Luc Anselin& Julie Le Gallo. 2006, 'Interpolation of Air Quality Measures in Hedonic House Price Models: Spatial Aspects', *Spatial Economic Analysis*, 1:1, 31-52, DOI: 10.1080/17421770600661337.
8. Philippe Le Goffe. 2000, 'Hedonic Pricing of Agriculture and Forestry Externalities', *Environment and Resource Economics*, vol.15, pp. 397-401.
9. Paliwal R., Geevarghese G. A., Babu P. R., Khanna P. 1999 'Valuation of Landmass Degradation Using Fuzzy Hedonic Method: A Case Study of National Capital Region', *Environmental and Resource Economics.* vol. 14, pp. 519-543.
10. Geoghegan J., Wainger A. L. and Bockstael N.E. 1997, 'Spatial landscape indices in a hedonic framework: an ecological economics analysis using GIS'. *Ecological Economics.* vol. 23, pp. 251-264.
11. Cavialhes et al. 2009, 'GIS-Based Hedonic Pricing of Landscape', *Environment and Resource Economics,* vol. 44, pp-571-590
12. Kong F., Yin H. &Nakagoshi N. 2007, 'using GIS and landscape metrics in hedonic price modelling of amenity value of urban green space: A case study from Jinan City, China', *Landscape and Urban Planning*, vol. 79 pp. 240-252.
13. Lee J.S. & Li M. 2008, 'The impact of detention basin design on residential property value: Case studies using GIS in the hedonic price modelling', *Landscape and Urban Planning*, vol. 89, pp. 7-16.
14. Damigos D., Kaliampakos D., 2003**,** 'Environmental Economics and the Mining Industry: Monetary benefits of an abandoned quarry rehabilitation in Greece', *Environmental Geology*, vol. 44, pp. 356-362.
15. Tyrvainen L., 1997, 'The amenity value of the urban forest: an application of the hedonic pricing method', *Landscape and Urban Planning*, vol. 37, pp. 211-222.
16. Poudyal N.C., Hodges D.G. &Merrett C.D. 2008, 'A hedonic analysis of the demand for and benefits of urban recreation parks', *Land Use Policy*. vol. 26, pp. 975-983.
17. Kuminoff N.V., Parmeter C.F. and Pope J.C. 2010, 'Which hedonic models can we trust to recover the marginal willingness to pay for environmental amenities?',*Journal of Environmental Economics and Management*. vol. 60 issue 3, pp. 145-160.

18. Sherwin Rosen. 1974, 'Hedonic Prices and Implicit Markets: 'Product Differentiation in Pure Competition', *Journal of Political Economy*, vol. 82 pp. 24-55.
19. Myers, N. R.A. Mittermeier, et. al. (2000) "Biodiversity Hotspots for conservation priorities". Nature 403:853-858, retrieved 6/1/2007.
20. Rocchini, Balkenhol, et. al. (2010) "Remotely-sensed spectral heterogeneity as a proxy of species diversity: recent advances and open challenges", *Ecological Informatics*, Vol 5 318-329
21. Nagendra H. and Ostrom E. (2011) "The Challenge of Forest Diagnostics", *Ecology and Society*, Vol. 16 (2): 20
22. Sharma S. and Roy, P.S. (2007), "Forest fragmentation in the Himalaya: A central Himalayan case study", *International Journal of Sustainable development and World Economics.* 14,2. Pg. 201
23. Roy P.S., Joshi P.K. et. al. (2006), "Biome mapping in India using vegetation type map derived using temporal satellite data and environmental parameters", *Ecological modelling*, 197 148-158.
24. Menon S. and Bawa K.S. (1997), "Application of GIS, remote-sensing and landscape ecology approach to biodiversity conservation in the Western Ghats", *Current Science*, Vol. 13. No. 2.
25. Kotha M. and Kunte P.D. (2013), "Land-cover change in Goa – An Integrated RS-GIS approach", *International Journal of Geoinformatics*, Vol. 9, No. 2.
26. Yadav P.K., Sarma K. and Dookia S. (2013), "The Review of Biodiversity and Conservation study in India using Geospatial Technology", *International Journal of remote Sensing and GIS*, Vol. 2, Issue 1.
27. Yadav P.K., Mohnish Kapoor, SarmaKiranmay (2012), "Land Use Land cover mapping, change detection and conflict analysis of Nagzira-Navegaon Corridor, Central India using geospatial technology", *International Journal of remote Sensing and GIS*, Vol. 1, Issue 2.

APPENDIX

The model proposed is as follows –

The price of land is written as a function of various landscape and in-situ variables.

$P = F (z_1, z_2, z_3, z_4, z_5 \ldots z_n)$

$= az_1 + bz_2 + cz_3 + \ldots kz_n + e$

Where a, b, c… k are beta coefficients obtained from the regression, and e is the error term while a_0 is the sum of all the intercepts (alpha).

The variables tentatively proposed are – (Kong et. al., 2007, Poudyal et. al, 2008 among others)

Environment characteristics:

1. Size of apartment
2. Number of rooms
3. Age
4. Market price of land at the time of purchase
5. Individual house or flat

Accessibility characteristics:

1. Distance to nearest green space
2. Distance to central business district
3. Distance to nearest shop/plaza
4. Distance from town centre
5. Distance from major road
6. Fragmentation – edge to interior ratio (Geoghagan et. al., 1997)
7. Diversity (Geoghagan et. al., 1997)
8. Type of nearest green space – 1,2 or 3 weighed
9. Green ratio in a 300m radius window (% of area that is green = green area/tot. area)
10. Fragmentation – no. of green patches in 500m radius window
11. No. of land use patches in 500m window
12. Type(s) of land use patches in 500m window
13. Environmental dis-amenity – mines/factories located in 1000m radius. = (no. of factories / average, distance from them) = (n/d average) = (n/(sum(di)/n))
14. Education environment – distance from school in 1000m radius

Using the aforementioned parameters, a questionnaire was drafted. The Questions and the answers from it have been tabulated below –

Landscape Characteristics:

675, 17.5, 3

House no.	No. of residents	Size of plot	Quoted price of land at time of purchase
1	3	325 sq. m.	Rs. 400/ sq. m
2	4	1500 sq. m.	Information not available
3	7	475 sq. m.	Rs.100/sq. m.
4	5	800 sq. m.	Rs. 13/sq. m.
5	4	277 sq. m.	Rs. 250/ sq. m.

House no.	land purchase yr.	No. of trees	No. of rooms	Building stories
1	1975	5	2	2
2	1992	25	5	2
3	1982	7	2	3
4	1983	10	6	2
5	1988	40	4	2

Behavioural questions – Impact of mining

House no.	Impact on water quality	Impact on livelihood	Impact on civic amenities	Impact on air quality	Impact on Health
1	-ve	+ve	No change	No change	No change
2	- ve	+ ve	- ve	- ve	- ve
3	- ve	+ ve	+ ve	- ve	No change
4	No change	+ ve	No change	- ve	- ve
5	No change	+ ve	No change	- ve	- ve

Behavioural questions – Biodiversity and its management

House no.	Should forests be preserved for posterity?	Should mining be allowed in protected area?	Should hunting be allowed for forest communities?	Should collection of forest produce be allowed?	Should tourism levels be increased |decreased | remain the same?
1	Yes	No	No	Yes	Increased
2	Yes, but controlled exploitation	Legal mining only	Yes	Yes	Increased
3	Yes	Restricted allowance	No	Yes	Remain the same
4	Yes	Yes, but away from forests	No	Yes	Increased
5	Yes	Yes	No	Yes	Remain the same

House no.	How many bird species are in Goa?	King Cobra in Goa?	Tigers in Goa?	How has biodiversity changed in the past decade?	How has awareness levels changed in last decade?	Have you visited a Wildlife Sanct.in Goa?
1	150	Yes	Yes	Decreased	Increased	Yes, 2-3 times
2	100	Yes	No	Decreased	Increased	Yes, 5-6 times
3	50	Yes	No	Decreased	Increased	Yes, once
4	100	Yes	Yes	Decreased	Decreased	Yes
5	100	Yes	Yes	Decreased	Increased	Yes